Cost allocation and incentive mechanisms for environmental protection in the coffee supply chain

Summarised results for decision makers in the industry

Based on reports by

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Section I 1.5 and Section III 2.1

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Imprint

Abstract: Cost allocation and incentive mechanisms for environmental protection in the coffee supply chain

The research project "Cost allocation and incentive mechanisms for the environment, climate protection and resource conservation along global supply chains" (project number 3722 14 101 0) commissioned by the German Environment Agency investigated (dis)incentives for and barriers to the implementation of environmental measures as well as the exchange of information between different actors along selected global supply chains. The project focused on five supply chains from raw material to the end product that represent key sectors of the German industry with a high potential for environmental and human rights risks: cotton-readymade garments; tin – tin solder; natural rubber – car tyres; coffee – coffee for consumption; iron ore – quality steel for automotive industry. It aimed to provide guidance to business and policy makers to facilitate the practical implementation of effective environmental upgrade measures along these global supply chains and to allocate the distribution of the resulting cost and benefits more equitably. This report consolidates the research findings for the coffee supply chain for retail and consumer brands. It is a compilation of texts already published in other reports with the purpose of informing decision makers in the coffee supply chain.

Kurzbeschreibung: Kostenverteilungs- und Anreizmechanismen für den Umweltschutz in der Baumwoll-/Textillieferkette

Das vom Umweltbundesamt in Auftrag gegebene Forschungsprojekt „Kostenallokation und Anreizmechanismen für Umwelt-, Klima- und Ressourcenschutz entlang globaler Lieferketten" (Forschungskennzahl 3722 14 101 0) analysierte (Fehl-)Anreize und Barrieren für die Umsetzung von Umweltschutzmaßnahmen sowie den Informationsaustausch zwischen verschiedenen Akteur*innen entlang ausgewählter globaler Lieferketten. Das Projekt konzentrierte sich auf fünf Lieferketten, die Schlüsselsektoren der deutschen Industrie mit einem hohen Potenzial für Umwelt- und Menschenrechtsrisiken darstellen und betrachtet diese vom Rohstoff bis zum Endprodukt: Baumwolle – Konfektionsware, Zinn – Lötzinn, Naturkautschuk / Autoreifen, Kaffee – Konsumkaffee, Eisenerz – Qualitätsstahl für die Automobilindustrie. Das Projekt soll Unternehmen und politischen Entscheidungsträger*innen als Orientierungshilfe dienen, um die praktische Umsetzung wirksamer Umweltschutzmaßnahmen entlang der globalen Lieferketten zu erleichtern und die daraus resultierenden Kosten und Nutzen gleichmäßiger zu verteilen. Dieser Bericht fasst die Forschungsergebnisse für die Kaffeelieferkette für Einzelhandels- und Verbrauchermarken zusammen. Der Bericht ist eine Zusammenstellung von Texten, die bereits in anderen Forschungsberichten veröffentlicht wurden, mit dem Ziel Entscheidungsträger*innen in der Kaffeelieferkette zu informieren.

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1   Introduction and background of the research project

The research project "Cost allocation and incentive mechanisms for the environment, climate protection and resource conservation along global supply chains", commissioned by the German Environment Agency, investigates (dis)incentives for and barriers to the implementation of environmental upgrading activities as well as the exchange of information between different actors along selected global supply chains. The report addresses the issue that the implementation of environmental upgrading activities is often accompanied by significant costs (both financially and in terms of resources and expenditure). Observations from the research conducted in the project confirm that these costs are often unevenly distributed among the actors involved in the setting of global supply chains - the costs are often higher for the less powerful and financially weak suppliers, while the benefits from the implementation of environmental protection measures (e.g. improved reputation) are focused to a greater extent on more powerful and financially stronger, larger purchasing companies. This can hinder the effective implementation of environmental and climate protection as well as cooperation between supply chain actors. For this reason, the report is intended to provide guidance to businesses and policy makers to facilitate the practical implementation of environmental upgrading activities along global supply chains and to improve the distribution of cost and benefits in the process.

The project focuses on global supply chains from raw material to the end product that represent key sectors of the German economy with a high potential for adverse environmental impacts. We analyse the following five supply chains:

► Cotton and the manufacturing of cotton-based ready-made garments

► Tin and tin solder for the manufacturing of electronics

► Natural rubber and car tyres for the automotive industry

► Coffee for retail and consumer brands

► Iron ore and quality steel for the automotive industry

Building on the findings this report will synthesise the overall project findings, ultimately resulting in a roadmap combining seven instruments that appear most promising to more equitably distribute costs and benefits and thus support the effective implementation of environmental upgrading activities in the global **coffee supply chain.** These instruments were chosen based on a qualitative assessment of all materials collected throughout the project implementation – consisting of an extensive literature review, workshops and interviews with practitioners and various industry experts. They were mentioned repeatedly as being the most promising approaches to environmental upgrading, cost-benefit sharing and cooperation between different stakeholders along global supply chains. Some are already in use, while most are not yet used or still in pilot phases in the analysed supply chains.

Chapter 2 contains a supply chain profile for the coffee industry. By focusing on the market design, e. g. market structures, pricing mechanisms, power structures in the value chain and barriers for mainstreaming environment protection in the supply chain, this chapter lays the ground for the analysis of how to promote sustainable supply chain management (SSCM) in the industry. Chapter 3 maps the main environmental impacts in the coffee supply chain and provides an overview of the SSCM instruments already in use by garment producers and their suppliers or that are currently emerging. Chapter 4 presents a roadmap for the introduction of SSCM instruments that can deliver meaningful incentives to reduce deforestation along the

coffee supply chain at all stages. The roadmap was created in close collaboration with a European retail chain that is known for its wide range of consumer goods, including textiles and fashion. Additionally, it is backed by research, interviews with other industry representatives and workshops.

By considering SSCM instruments and related incentive mechanisms that go beyond current practice, the report aims to support industrial actors as well as those who regulate, finance or otherwise support these sectors in furthering an equitable distribution of costs and benefits, supporting the effective implementation of environmental upgrade activities along global supply chains.

2   Supply chain profile for coffee

This chapter is an excerpt of the report "Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Analysis of the cotton, tin, natural rubber, coffee and iron ore supply chains" (Strasser et al. 2024). The supply chain profile for the coffee supply chain contains background information on the commodities, an explanation of the market structure, the functioning of the value chain, pricing mechanisms and power relationships, an indication of how the industry addresses its environmental impacts as well as an outlook on market, consumer and technology trends that will likely shape the future composition and functioning of the value chain. The chapter ends with lining out selected institutional incentive mechanisms and barriers for environmental upgrading of coffee supply chain.

2.1   Background

Coffee represents one of the most popular drinks in the world as well as one of the most extensively traded commodities with a diverse production base that spans 58 countries. 21% of the world's coffee is produced on large estates and farms (>50 hectares); 19% comes from mid-sized estates and farms (5-50 hectares); and the remaining 60% comes from approximately 12.5 million smallholder coffee farms (and households) with less than 5 hectares of land (Dan Rushton 2019). Although the industry provides a source of income to 100 million people globally, it faces issues related to environmental pollution due to chemical use and poor labour practices. At the same time, many actors across the coffee value chain are vulnerable to climate change and climate-change induced price fluctuations (Dzebo and Adams 2023).

The international coffee trade began in the early 20th century, with Brazil initially dominating the market. Brazil's control extended until the Second World War, when other Latin American countries also became involved. In 1962, the first international coffee agreement (ICA) was signed, establishing target prices and export quotas. However, the ICA quota system collapsed in 1989, because sustaining the expense associated with surplus stock and excess production capacity became unmanageable (Pichop and Kemegue 2006). The subsequent dismantling of supply management organisations in producing countries led to a shift in power dynamics, with roasters gaining in bargaining power and the value chain becoming more buyer-driven (Rebeca et al. 2022).

Germany, as the largest importer of green coffee beans in the EU, has a substantial roasting industry that caters to both the domestic and European markets (CBI 2022a). In the year 2021, Germany imported a significant quantity of 1.2 million tonnes of green coffee. Additionally, being one of the largest exporter of coffee products, Germany exported a total of 255.895 tonnes in the same year (Statista 2023e). Germany relies completely on imports, mostly from countries like Brazil and Vietnam. In 2022, Germany imported coffee products worth €5.4B (Statista 2023e). This makes Germany the second-largest importer of coffee in the world after the U.S. (Statista 2023f). Given the high reliance on suppliers of coffee, the following profile focuses on the supply chain of coffee from farming to its sale by retailers/consumer brands.

2.2 Market structure

Brazil, Vietnam, and Colombia are the leading coffee-producing countries, contributing significantly to the global coffee supply. On the other hand, the EU and the U.S. serve as the largest consumer and importer markets, driving the demand for coffee on a significant scale (FAO 2023). In 2021, the countries with the largest cultivation area for coffee are Brazil, Indonesia, Côte d'Ivoire, Colombia, Uganda, Ethiopia and Vietnam (Statista 2023d).

Coffee is overwhelmingly traded in green (unroasted) beans and roasted in the consumption destinations, mostly because of quality reasons, which limits the ability of producing countries to capitalise on value-adding activities. This set-up is supported by differential tariff structures for green and roasted coffee in importing countries (i.e. tariff escalation), and reinforced via roasters' preference for keeping control over the taste profiles of their blends, in which they mix coffee from various origins. However, there are also technological and logistic reasons for this set-up, including, in some origins, the lack of financial and human resources and infrastructure (e.g. reliable electricity) for large-scale processing activities, as well as the relatively shorter shelf-life of roasted coffee compared to green, and therefore preference for roasting closer to the consumer demand (ICO 2011). The top ten countries for green coffee exports are shown in Figure 1, while Figure 2 presents the top ten for roasted coffee.

Figure 1   Top 10 export countries for unroasted coffee in 2021
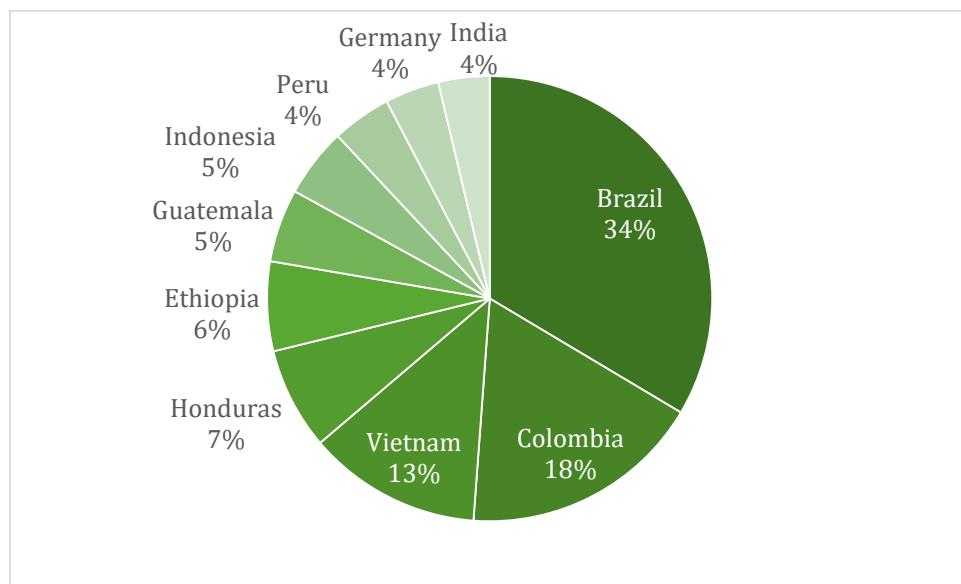
Source: adelphi, based on information from OEC 2023

Figure 2   Top 10 export countries for roasted coffee in 2021
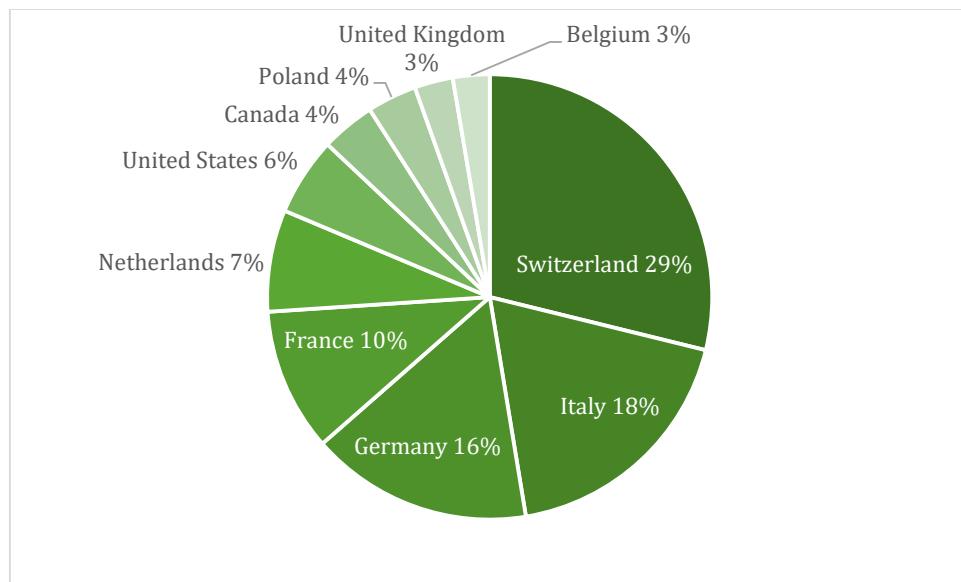
Source: adelphi, based on information from OEC 2023

In 2020/21, Europe was the primary export destination for all forms of coffee, accounting for an average of 46% of exports across different regions, with a range between 38% and 53%. Following Europe, North America and Asia & Oceania held the positions of second and third most important destinations. The geographical proximity and compatibility between the coffee produced and consumed played a significant role in making North America the main recipient of exports from Latin America. Despite comprising 60% of the global population in 2020, Asia & Oceania held the third spot in terms of coffee export destinations. This can be attributed to the relatively underdeveloped local coffee market in Asia and the presence of domestic coffee supply, which limits its prominence as a destination for coffee exports (ICO 2011).

Germany is the third-largest re-exporter of coffee after Switzerland and Italy, followed by France, the Netherlands and Poland in the EU (see Figure 2). At the same time, Germany imports a significant amount of both green and roasted coffee (see Figure 3 and Figure 4). On the global scale, Germany is the second-largest importer of green coffee behind the U.S., followed by Belgium, Italy, and Canada, as seen in Figure 3. Germany was the third-largest importer of roasted coffee in 2021, after France and the United States (see Figure 4).

Figure 3   Top 10 import countries for unroasted coffee in 2021
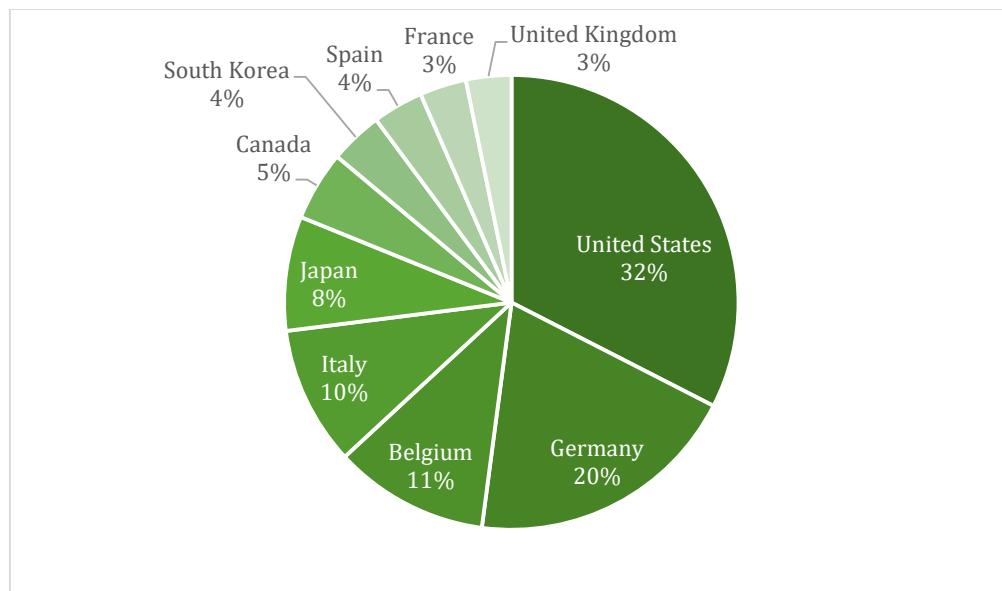
Source: adelphi, based on information from OEC 2023

Figure 4   Top 10 import countries for roasted coffee in 2021
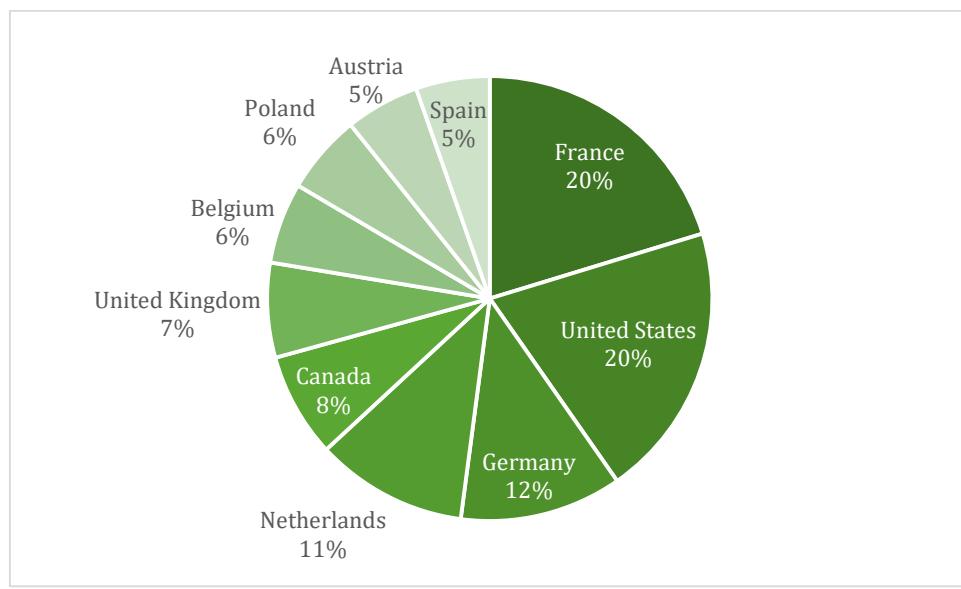
Source: adelphi, based on information from OEC 2023

In the year 2020/21, global coffee consumption reached 165.4 million bags (green, equivalent to 9.924 million tonnes). The leading consumer region, Europe, taking a 32% market share, witnessed a decline of 3.6%, whereas North America's market contracted by 0.9%. On the contrary, Asia & Oceania and Africa exhibited robust growth rates, expanding by 9.1% and 3.1%, respectively. The shifts in consumption patterns, marked by a rise in retail and at-home consumption and a decrease in out-of-home consumption, coupled with a thriving global economy, collectively contributed to the coffee consumption increase (ICO 2021).

2.3   The coffee value chain

The coffee value chain is highly complex due to its lengthy production steps and its geographical distance between downstream and upstream actors (Marescotti and Belletti 2016). It has numerous production stages and involves various stakeholders, ranging from farmers to end consumers. The coffee value chain often faces scrutiny for its sustainability and accountability practices. In particular, the industry's close association with economically disadvantaged regions, where coffee extraction takes place, has been a subject of criticism (Candelo et al. 2018).

Figure 5 represents an illustration of the coffee supply chain with the involvement and interaction of the various actors. Although there are very strong relationships between origin and destination countries, the actors in the coffee supply chain can be divided into two groups: ones in production countries and the others in the consuming countries.

Figure 5:   The coffee supply chain
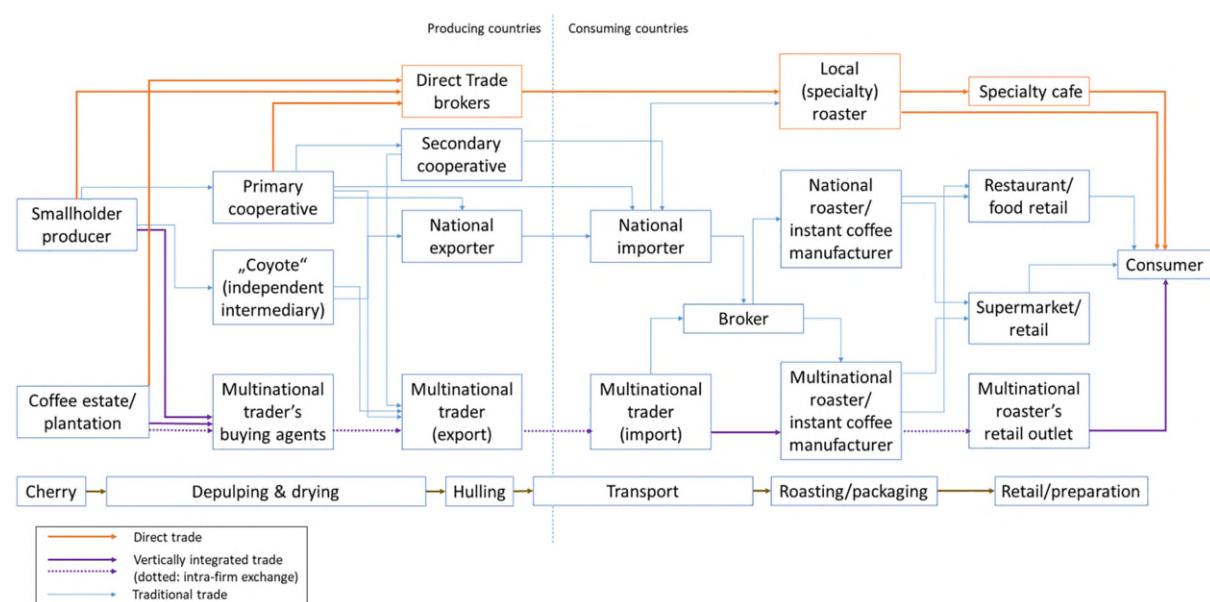
Source: Grabs and Carodenuto see1)

The coffee supply chain faces several vulnerability factors that industry, governmental and NGO actors grapple with. They encompass inadequate education, intricate and unstable political and economic conditions in certain countries. In addition, the volatility in markets and pricing, diminished trading capabilities, weakened negotiation power, inequality in information exchanging, the impacts of climate change, and a deficiency in business continuity are also contributed to the supply chain vulnerability.

The coffee industry contributes to negative environmental impacts across supply chain, from cultivation to roasting and end-of-use. Table 1 shows the environmental impacts that are common in the supply chain and therefore relevant for the industry. This does not mean that every impact listed will occur in every coffee supply chain.

Table 1:   Main environmental impacts in coffee value chain

Supply chain segments	Environmental impacts
Cultivation & harvesting	Deforestation: the relocation or expansion of coffee farms may lead to the clearance of forests. Deforestation destroys vital habitats, contributes to biodiversity loss, and

Supply chain segments	Environmental impacts
	increases greenhouse gas emissions. This is of particular concern for the future as it is expected that coffee production will move to higher altitudes, which are currently forested.
	Water consumption and pollution: coffee production requires substantial amounts of water for irrigation (though most coffee is currently rain-fed). Improper wastewater management can lead to water pollution, including contamination from agrochemicals and processing byproducts.
	Soil degradation: intensive coffee farming practices, such as the use of agrochemicals and monoculture plantations, can lead to soil erosion, nutrient depletion, and decreased soil fertility. This can negatively impact long-term agricultural productivity and ecosystem health.
Processing and Roasting	Energy consumption and greenhouse gas emissions: coffee production involves energy-intensive processes, such as drying, milling, and roasting. The energy sources utilised, such as fossil fuels, can contribute to greenhouse gas emissions and climate change.
	Waste generation: coffee processing leads to significant amounts of waste (including pulp, husks, packaging waste and wastewater) and inadequate management of the produced waste can result in pollution.

Source: adelphi, based on information from ICO (2020)

Figure 6 shows a summary of the key countries in the coffee value, from cultivation to consumption markets.

Figure 6:   Selected key structures and processes of the natural coffee value chain
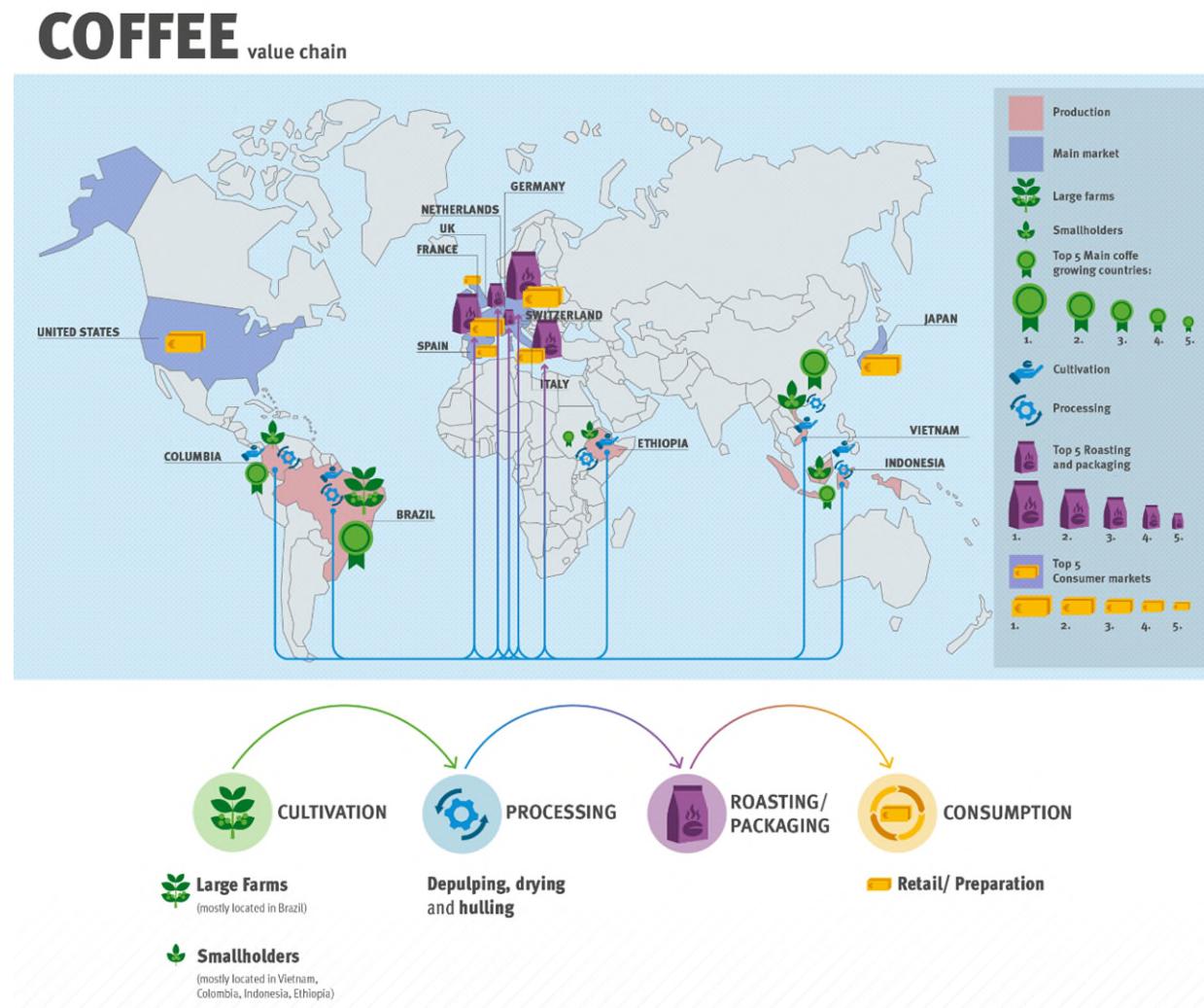
Source: adelphi, based on material and data from this text

2.4   Pricing

The coffee value chain is typically characterised as buyer-driven, meaning that the buyers of the good in question – in this case, coffee roasters – have greater power than mid-stream actors or producers and can influence contract terms and conditions. In the coffee sector, the power of roasters stems, on the one hand, from their high consolidation – only few actors make up over 40% of the retail market, and consolidation has increased in recent years (Grabs 2020). On the other hand, their value chain position close to consumers gives them the power to frame the narratives of what types of coffee are perceived as high quality or sustainable and simultaneously capture the differential price paid by consumers for such goods. Grabs and Ponte (2019) show that, even in a changing market environment, roasters drew on various sources of power to maintain the upper hand in setting expectations that cascaded down the chain without taking on significant shares of costs. These result in asymmetrical price transmission in the coffee supply chain (Ghoshray and Mohan 2021). Moreover, compliance costs are typically passed to producers; even when roasters fund development projects that assist producers on the ground, these are usually small in scale and do not cover the majority of their supply. The funding for such projects also usually comes out of a separate CSR budget, rather than being priced into the good of the commodity itself. Even in the case of certification schemes, premiums tend to be negotiated based on supply-demand dynamics rather than an aim to cover compliance costs (Grabs 2020).

To understand the distribution of costs and added value, it is informative to understand the way prices are set in the coffee market. For reasons of risk management and hedging, coffee – among other commodities – is traded on the coffee futures market (New York in the case of Arabica, London in the case of Robusta). The expectation is that the prices of futures contracts converge with spot market prices upon the time of delivery. Contracts for physical green coffee deliveries thus usually reference futures prices plus/minus a differential based on the country or anticipated quality level, rather than specifying prices outright. The lack of region- or even country-specific futures prices means that different producing origins with very different production costs compete against each other on the world market and that their prices are linked to each other. For instance, if Brazil has a high output, world market prices will decline to reflect this; while the highly efficient Brazilian producers (larger farm sizes on average and possibly using mechanical harvest) may still be able to cover their costs, producers with higher costs – e.g. in Central America – will not and will have to weather long periods where prices lie below their production costs. Speculation on futures markets may further exacerbate price volatility, though that relationship is still contested (Aliaga Lordemann et al. 2021).

Beyond this equalising effect of futures markets on green coffee prices, a lot of value is added and captured during the roasting, packaging, marketing and retail stages of the value chain, which tends to occur in consuming countries and via multi-national roasters who own a wide variety of brands that target various consuming markets. The contrast is particularly stark in out-of-home consumption, where the share of coffee only makes up a fragment of the cost of a cup, with other costs such as ingredients, e.g. milk, labour, taxes, rent of the premises, and overall market and business strategy making up a much greater proportion. Overall, the current estimate suggests that the average export value of green coffee constitutes less than 10% of the $200 to $250 billion in revenues generated within the coffee retail market (Panhuysen and Pierrot 2020).

The rise of demand for higher quality and greater knowledge of producer stories has allowed for the development of a specialty coffee niche, where producers of coffees of extraordinary quality are able to access buyers directly – e.g. via direct trade channels or the Cup of Excellence auctions – and capture higher prices that small-scale, specialty roasters pass on to highly

differentiating consumers. The premium status of specialty coffee hinges on the establishment of close relationships between coffee companies and farmers. These relationships are forged by emphasising the coffee's origin and quality, traceability, and potential improvements in the production process. Consumers of specialty coffee are willing to pay higher prices for their brew and, in return, seek knowledge about the beans' origin and cultivation methods. Consequently, the specialty coffee industry aims to communicate the value of origin-centric coffee to enhance its perception of premium quality to increase consumers' willingness to pay higher prices for coffee and the experiences associated with it (Barbosa Escobar et al. 2021). Yet, this model also has its drawbacks. On the one hand, Borrella et al. (2015) find that, while producer prices are higher, they do not receive a higher share of the total price paid by the consumer, meaning that the proportional value capture has not changed. Fischer et al. (2021) show that the high-quality wave may undermine solidary and cooperative values among producer groups as it introduces competitive dynamics on the ground. On the other hand, small-scale specialty roasters themselves often do not have particularly sustainable business models, have to survive on thin margins, and often rely on external financing to survive long-term, whereas the vast majority of consumers are highly price-sensitive and reluctant to pay extra. Additionally, there are challenges related to supply chain vulnerability, which is susceptible to changes in import regulations (such as maximum residue levels), quality fluctuations, and a lack of professionalism in logistics management (lower productivity might increase costs).

2.5 Power relationships

Among the various participants in the coffee supply chain, the most vulnerable are often groups of local suppliers, typically unorganised smallholder farmers who supply coffee to other intermediaries like fellow farmers or collectors/traders. Given that cherry coffee has to be processed very quickly, they have little ability to store coffee waiting for better prices and have to accept the day-to-day price offered to them; often they are also in debt, having purchased inputs from the same intermediaries against the promise of future coffee sales and thus have no ability to choose their buyer. They depend on other actors, especially, large corporations within instable markets. Smallholder farmers also face severe consequences from climate change by cultivation activities, which seriously affect their livelihoods. They have to cope with information asymmetries and gaps when establishing relationships with other actors. This lack of information as well as their fragmentation, remoteness, and lack of primary processing capacity reduces their trading and negotiating capabilities. First-level traders frequently exploit these power imbalances by offering lower-than-market prices and underestimating coffee quality (Candelo et al. 2018). It is also difficult for unorganised smallholder farmers to attain sustainability certification due to their lack of capacity and resources. Even beyond smallholder farmers, landless farmworkers are the weakest as their compensation also relies on the farm income and is often limited in the case of small-scale farms while on large farms they may live in exploitative conditions (Specialty Coffee Association 2016).

In contrast, organised smallholder farmers (cooperatives or farmer groups) are able to pool their crop and overcome the fragmentation that gives commodity producers low bargaining power to a certain extent; their success relies on the quality of cooperative/group management, which can vary significantly. Some cooperatives are also used as vehicles to capture value for their leaders, which negates the potential beneficial function. As mentioned in the previous section, small-scale producers that focus on quality coffee and/or that process coffee at home into dried parchment coffee also have tendentially more power, as they can store their coffee and wait to sell until prices improve. Higher quality is also associated with higher prices, especially if producers score 85 points or above (out of 100 of the standardised scoring system) and have more power in pricing negotiation.

With other actors in the supply chain, traders tend to have power over farmers but not over roasters. Roasters tend to have power over traders. And retailers have more power over roasters, as retailers have influence over the manner in which coffee from roasters is presented to customers. The power pattern is that large actors of all categories (growers, traders, roasters) tend to be more powerful by virtue of their size and market influence.

Depending on types of coffee and types of actors in the supply chain, there are both strategic and occasional suppliers/buyers. For high quality or certified coffee, strategic coffee suppliers/buyers are established. It is also common that traders (small or large) and roasters have both: a stream of certified or otherwise "sustainable" volumes that can be traced better and where longer-term relationships exist, which typically makes up a small share of total volume; and then the larger share which is very much based on a commodity system where producing origins and individual producers are interchangeable.

The power relationships in a global value chain is further elaborated by Ponte (2019) in his book titled "Business, Power and Sustainability in a World of Global Value Chains" and the study by Grabs and Ponte (2019). Besides bargaining power and institutional power, demonstrative and constitutive power can have some influence in shaping the coffee value chain, in particular (and other GVCs in general). The demonstrative power creates a demonstration effect among competitor suppliers. It works through informal transmission mechanisms between individual actors and is presented by conventions and best practices, including ones on sustainability management – for instance, the demonstrative effects of Starbucks purchasing certified sustainable coffee or Procter & Gamble buying fair trade coffee. On the other hand, constitutive power is found in "broadly accepted norms, conventions, expectations and best practices" (Ponte 2019) and it forms what is acceptable and desirable. In coffee GVCs, this power, for example, is related to effects of new consumption patterns, which are summarised in Table 2.

An examination of the GVC in the coffee sector reveals an imbalance in the global value distribution. The governance structure of the coffee GVC is currently experiencing "diversification and re-consolidation" (Grabs and Ponte 2019). The remarkable growth of the specialty coffee market and the emphasis on high-quality coffee have enabled companies like Starbucks, Keurig Green Mountain, and smaller local specialty roasters to expand their market shares. The specialty segment of the coffee market has been recognised as a strategic long-term investment opportunity. The increased competition in the market has prompted other roasters to strengthen their product portfolios. According to Grabs and Ponte (2019), the recent shifts in the coffee GVC have led to more diverse coffee products. These changes potentially empower producers in coffee-producing countries, especially when introducing new specialty coffees. However, despite these developments, the ongoing efforts to re-consolidate the significant imbalances in bargaining power and the demonstrative power remain. Consequently, those changes suggest that buyers are able to enforce stricter terms on their suppliers (Grabs und Ponte 2019). Based on the study by Gereffi et al. (2005), and in reference to other studies, such as Grabs and Ponte (2019) and Lima and Lee (2023), the governance structure of the coffee GVC is considered as both a market and relational governance type.

2.6   Addressing environmental impacts by voluntary measures

Since the coffee industry is highly susceptible to the impacts of climate change, small-scale farmers who lack the financial means to relocate their coffee production in response to changing conditions face significant challenges. This situation may result in the unfortunate circumstance where farmers are forced to cease coffee cultivation entirely (ICO 2020). Fluctuating weather conditions, such as higher temperatures and increased variability within seasons, negatively affect coffee yields and quality. Furthermore, climate change leads to reduced water availability

and the emergence of new pests and insects, adding further pressures to coffee production in many producing countries.

Research conducted by Sachs et al. (2019) indicates that climate change could lead to the loss of 63-75% of available land for coffee farming within the next three decades, higher than that from the study of Bunn et al. (2015) at 50% by 2050. Consequently, coffee plantations will need to relocate to more favourable areas. However, small-scale farmers may face challenges in migrating, potentially resulting in the abandonment of coffee production (Sachs et al. 2019). As coffee production shifts from lower altitudes to higher altitudes, which are predominantly forested areas, deforestation becomes a consequence. Until recently, coffee has played a relatively small role in global deforestation (Pendrill et al. 2019). Mitigating the issues of deforestation, improvement of local regulations (or implementation) for land conservation, and import regulations to ensure that commodity supply chains are completely deforestation-free may be needed (Basik Treanor and Saunders 2021).

A study by van Rikxoort et al. (2014) highlights that the carbon footprint of coffee is influenced by various factors. These include emissions stemming from soil management, with a notable emphasis on drained organic soils and forest clearance (Barthelmes 2018; Kruid et al. 2021). Additionally, fertiliser production and methane emissions formed during pulping and fermentation from wet processing (ICO 2020) also contribute to carbon footprint of the coffee production. The excessive use of fertilisers and other agrochemicals leads to soil degradation. This phenomenon has emerged as a consequence of the trend toward "technified" or very high productivity systems ("high-input, high-output"). This approach is particularly prevalent in major coffee-producing regions like Brazil, Vietnam, and Colombia. However, plenty of producers around the world use less inputs than would be optimal for them.

In coffee farms around the world, shade trees are planted to protect the coffee plants. These trees offer various benefits, including protection against temperature fluctuations, erosion, and excessive radiation. However, many studies, for example from Muñoz-Villers et al. (2020), Piato et al. (2020) and Koutouleas et al. (2022), suggest that while the use of shade trees has its advantages, there may also be trade-offs in terms of productivity and quality.

Wet processing of coffee requires substantial amounts of water, and the wastewater produced during fermentation often contains high levels of acidic nutrients. Small-scale farmers who perform home processing often dispose of this water by infiltrating it into the soil, which can result in the contamination of downstream water supplies for both humans and animals (ICO 2020). Using large volumes of water can be a consequence of technological path dependence (wet milling established at a time of water abundance) and lack of local regulation (implementation), and also price pressure (better practices cost money). Alternative systems (ecological wet mills (Kraft n.d.) or dry mills) exist, but investment costs are often too high for local actors and need to be covered by third parties such as donors

Assuring environmental standards

There have been substantial efforts to improve the coffee sector's sustainability by training farmers in sustainable practices (e.g. integrated pest management (Oliveira et al. 2021; Bikila Takala 2023), or agroforestry) and providing capacity-building on a number of issues (e.g. financial literacy, book-keeping, gender equality, youth empowerment). Such training programmes are offered through development cooperation, company-internal projects (e.g. Tchibo Truemorrow initiative (Tchibo n.d.)), sector initiatives (e.g. the Global Coffee Platform's Collective Action Initiatives (Global Coffee Platform n.d.)), as well as more systematised certification and verification schemes. Moreover, agri-businesses and investors operating in the

coffee supply chain can use the OECD-FAO Guidance for Responsible Agricultural Supply Chains as it offers a unified framework and universally applicable standard for methodically recognising, evaluating, and addressing adverse effects on both people and the environment within their supply chain (OECD and FAO 2016).

There are several certification schemes for coffee (see Figure 7). The most widely used are Fairtrade (both Fairtrade International and Fairtrade U.S.), Rainforest Alliance (UTZ merged with Rainforest Alliance in 2018), Common Code for the Coffee Community (4C), USDA Organic, and the European Union organic certification. Roasters have also set up their own company-internal standards such as Starbucks' C.A.F.E Practices and the Nespresso AAA programme.

Figure 7   Selected certifications in the coffee supply chain

Source: CBI (2022c)

Among the various certificates available, there is still a notable gap in comprehensively addressing GHG emissions, which have become a significant concern. Each certificate has its own features. For instance, Rainforest Alliance addresses a wide range of environmental and social aspects, including deforestation, biodiversity, soil quality improvements, increased income, and improved conditions for workers. The Smithsonian Bird Friendly standard sets high standards for agroforestry production with the goal of conserving habitat and protecting migratory songbirds. However, the broader protection of biodiversity has only been marginally addressed by these certifications.

Until recently, environmental improvements have been mainly demand-driven and framed as CSR to use as differentiator for consumers. Buyers will require certification and signal that demand to traders, who then look for the respective volumes, though a number of producers also pre-emptively adopted certifications because of an expectation of higher prices and improved market access (Grabs et al. 2016). When certification is demand-driven by traders, traders would often be the certificate holders and support producers in getting the certification, particularly regarding larger capital expenditures, but they would also select producers that were close to meeting the standard to minimise such costs. When producers decide by themselves to get certified, they assume all the costs. Certification premiums are generally small and are not seen to cover the costs of compliance (Grabs et al. 2016; Grabs 2020).

The assurance of environmental and social certification standards is generally provided via third-party auditors that are selected and paid by the certificate holder. This generates conflict-of-interest problems as all actors involved have an aligned interest in finding farms compliant, as auditors want to generate multi-year business relationships with certificate holders. Industry

insiders speak of widespread cases of fraud, rent-seeking, and a lack of confidence in third-party certification's traceability and assurance systems.

At present, buying companies are expected to take on responsibility, especially to comply with due diligence regulation. But, the mechanism of cascading expectations down is the same, as changes have to happen on the farm-level.

A movement toward broader supplier screening as has happened in other industries is only just starting to happen in the coffee sector on a wider level, particularly in response to the *EUDR*.

2.7   Current/future trends and developments

The European coffee market is witnessing significant changes, including the growing demand for specialty coffee, expansion of trading company portfolios, and the rise of direct trade and relationship coffee models. Online sales and subscriptions are becoming popular, and consolidation is evident in the mainstream coffee segment. On the consumer side, there is increasing interest in high-quality and sustainable coffee, a curiosity about coffee origin, and a concern for social and ecological impacts. Certified coffees and decaffeinated options are gaining traction (CBI 2020b). In terms of technology, digital platforms and marketplaces facilitate direct trade, while blockchain can be used to enhance transparency and traceability (Singh et al. 2022). Efforts are being made to address the environmental impact of coffee capsules through recyclable and compostable solutions, as well as capsule recycling initiatives. These trends reflect the industry's commitment to transparency, sustainability, and innovation.

The COVID-19 outbreak showed that the coffee GVCs are fragile. They faced challenges due to a diminished labour supply, disruptions and delays in the supply chain. Many producing countries have health infrastructure below the global average, limiting their ability to respond effectively to health crises. Additionally, when the diversification in the supplies is lacking, stocks and inventories are diminished, and logistics operations are redundant, the overall system is susceptible to shocks (ICO 2020).

Table 2:   **Regulation, market, consumer and technology trends**

Regulation trends	▶ Rise of Due Diligence and Green Claims requirements from the EU, Germany, … ▶ Require large companies to increase transparency on human right issues and implement human rights due diligence in their operations and their supply chain ▶ Require more collaborative efforts among key stakeholders
Market trends	▶ Specialty coffee is growing in the European market, which has led to large trading companies expanding portfolio with specialty coffees ▶ Specialised independent trading companies import small volumes of high-quality coffees ▶ Micro-lot exports of high-end coffee roasted in the origin country ▶ Direct trade and relationship coffee models are growing ▶ Online coffee sales and subscriptions are increasing ▶ Increasing consolidation in the mainstream coffee segment
Consumer trends	▶ Increasing interest in high-quality and sustainable coffee ▶ Growing interest in coffee origin ▶ Buying single origin (single variety) coffee

Regulation trends	► Rise of Due Diligence and Green Claims requirements from the EU, Germany, … ► Require large companies to increase transparency on human right issues and implement human rights due diligence in their operations and their supply chain ► Require more collaborative efforts among key stakeholders ► Interesting in "selling of stories" on the coffee packages ► Concern about social and ecological impacts ► Health living trends from health benefits from appropriate coffee intake ► Growing interest in decaffeinated coffee and specialty decaf coffees due to concerns about high caffeine intake.
Technology trends	► New fermentation techniques: carbonic maceration, aerobic fermentation, anaerobic fermentation ► Digital platforms and marketplaces connect producers and roasters ► Online trading sites facilitate direct trade ► Blockchain is gaining ground as a tool to increase transparency and traceability ► Increased traceability and digital tools enable consumers to connect with coffee farmers and understand the environmental impact of their consumption ► Industry efforts to address the negative environmental impact of coffee capsules through recyclable, compostable, and bio-based solutions, as well as initiatives for capsule recycling

Sources: adelphi, based on information from CBI (2022c)

2.8 Institutional incentive mechanisms and barriers

Trade Policies

Since the International Coffee Agreement's quota system collapsed in 1989, the global coffee market is organised in a liberalised, free market fashion, with little appetite from most producing or consuming countries to return to supply management. For instance, Tanzania has issued their regulations around coffee export and marketing. In spite of a liberalised, free market context, tariff escalation continues to be an issue, with the EU, Switzerland, the UK, and Japan (but not the U.S.) implementing higher tariffs for roasted, decaffeinated, and soluble coffee than for green coffee according to the WTO's most-favoured-nation (MFN) rates. While bilateral and multilateral Free Trade Agreements and other preferential trade agreements (e.g. Everything But Arms, GSP+, etc.) reduce the de-facto tariff barrier for many exporting countries, this is not true for all countries and products – as an example, Brazil is charged the EU's standard MFN rate on all exports of soluble and instant coffees (ICO 2011).

Environmental regulations in supplier countries

There is a wide range of environmental legislation in producing countries, which tends to correlate with their overall governance performance. In most cases, coffee is not regulated separately but as one agricultural activity of many, which may affect forest cover and pollution levels (e.g. Brazil's Forest Code). In other instances, there are country-specific path dependencies that led to a specific outcome (e.g. in Costa Rica, where the vast majority of coffee is wet-milled, a voluntary agreement between all mills in 1992 led to the installation of water

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treatment plants in each mill). While it is difficult to provide a comprehensive overview, in general environmental regulations in producing regions are weaker (e.g. with regard to approved pesticides, the use of personal protection equipment, or natural habitat conservation) and less well enforced than in the Global North (Grabs 2020).

Environmental regulations in consumer markets

In consumer markets, safety and environmental requirements play an important role on regulating imported coffee. As a result, imported coffee must meet criteria for food safety, food contaminants, quality, packaging and labelling, CSR and sustainability. These encompass adherence to (future) environmental and sustainability regulations in the EU, such as CSDDD, CSRD and EUDR. Among them, EUDR is considered to have the greatest potential to improve traceability in certain commodities classified as deforestation-risk commodities (natural rubber, soy, beef, palm oil, wood, cocoa, coffee). It could have a major impact on coffee exports, especially for smallholders and in those situations where there is currently little traceability on deforestation issues at the farm level.

While environmental regulations vary and consumption patterns differ, environmental and sustainability strategies for compliance to those regulations are still highly concentrated in multinational corporations such as Nestlé, JAB Holding and similar entities. Nevertheless, it is worth noting that these strategies generally align with the prevailing trends in national-level environmental legislation (Grabs 2020).

Voluntary standards/commitments

In the wake of liberalisation and under pressure from structural adjustment programmes, many producing countries (especially in Africa and Asia) dismantled their coffee institutions (e.g. marketing boards, coffee councils) and left coffee production up to individual farmers' choices. Other producing countries, especially in Latin America, however, refocused their institutions and created powerful quasi-state entities (e.g. the Federación Nacional de Cafeteros de Colombia, the Instituto del Café de Costa Rica) that provide institutional support, e.g. in the form of oversight of coffee contracts and pricing (Costa Rica), and the provision of distributional payments and social investments funded through export taxes (Colombia) (Grabs 2020). In recent years, a number of producing countries have also re-strengthened coffee-focused government authorities as well as public-private partnerships (e.g. the Honduran National Coffee Platform, supported via the Global Coffee Platform). Such institutional arrangements, which bring together public and private stakeholders on a national level, may be important arenas to socialise new (environmental) requirements from importing countries and look for sectoral action to address them.

On an international level, there have also been continued efforts to create multi-stakeholder partnerships and forums for public-private interaction. Key arenas here are the Sustainable Coffee Challenge, the Global Coffee Platform, and the International Coffee Organization's Public-Private Task Force. In addition, industry associations such as the Specialty Coffee Association (SCA) and the European Coffee Federation provide opportunities for sectoral actors to connect. While these arenas have been important to raise awareness and achieve low-hanging-fruit wins, the presence and dominance of large industry actors limits the ability of these forums to initiate structural change that tackles existing power relations.

Outlook

Overall coffee demand in the U.S. and European market is consolidated but there will likely be a continued shift from conventional to specialty coffee and from roasted beans to capsules (which lowers the volume/cup and hence lowers potentially import volumes) according to several

market studies such as by Grand View Research (2021), Market Research Future (2022), and statistic data by Statista (2023a).

Small-scale mechanisation (e.g. hand-held harvesting machines (Perfect Daily Grind 2017), small tractors able to work on hillsides) might increase labour productivity, especially important as some regions are battling labour shortage especially during harvesting time. Improved cultivation techniques might boost the yield as well. Shade production might reduce the coffee quality and productivity of coffee fields unless they are carefully implemented. However, there may be a renaissance of shade production systems as more resilient production systems capture carbon on-farm. These systems allow for insetting and lower carbon footprint. The development of disease-, heat-, or drought-resistant varietals is likely to ensure more even harvest under climate change conditions. But it requires producers to replant, which can lead to breaks in income for several years.

Despite the growing consumer demand for coffee and increased production in coffee-producing nations, the primary influence and control in the coffee industry still predominantly reside in importing countries, mainly developed economies. This is where significant value is added to the coffee through processes like roasting, packaging, marketing, and retailing by multinational coffee roasters. Consequently, inequalities in the coffee GVC are typically divided between two main groups: the coffee-producing countries and the coffee-consuming countries. Numerous initiatives spearheaded by multinational coffee roasters have been established with the aim of supporting coffee farmers and promoting sustainability in the coffee supply chain. However, it should be noted that, with the new regulatory requirement in consumer countries, such as for corporate sustainability due diligence or the substantiation of green claims in EU, small and medium-sized suppliers can face significant challenges, especially because they generate insufficient turnover to justify the establishment of audit and control systems or the expenses related to reporting to regulatory authorities. Furthermore, as seen in case of German importers, there might be an increase in the costs linked to the compliance of the laws, such as German supply chain act. Consequently, German import companies might reduce their involvement or adjust their procurement volumes in specific countries (Felbermayr et al. 2021).

3 Sustainable supply chain management approaches and instruments

This chapter is an excerpt of the report "Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Business approaches and instruments of sustainable supply chain management" (Grüning et al. 2024). The chapter shows which approaches and instruments for SSCM are used in the coffee supply chain and to what extent. The information is based on desktop research, interviews with industry experts and consultation with an Expert Advisory Board comprising individuals from business, civil society and academia. The chapter concludes with a matrix in which the observed and described SSCM approaches and instruments are categorised.

3.1 Main environmental impacts in the coffee supply chain

The sustainability of the coffee supply chain is influenced by various social, economic, and environmental factors. Environmental concerns, particularly related to land use, carbon and water footprint, and waste, play a significant role. Different segments of the supply chain contribute to distinct environmental impacts. Table 3 provides a summary of these impacts along to the various stages of the supply chain.

Land and land use: coffee cultivation is associated with a critical issue – **deforestation**. Deforestation not only exacerbates other environmental problems, it also serves as a catalyst for them. It is identified as the second-largest contributor to anthropogenic greenhouse gas emissions and a major driver of **biodiversity loss** (Pendrill et al. 2019). The surge in international demand for agricultural commodities is the primary force behind deforestation and its subsequent adverse effects on the environment. It was estimated that the top ten global coffee producers (Brazil, Vietnam, Colombia, Honduras, Ethiopia, among others) emitted 21 million tons of CO_2 due to deforestation associated with coffee production in 2017 (Naomi Basik Treanor and Jade Saunders 2021). Furthermore, the intensive farming practices, such as the excessive application of agrochemicals like pesticides and fertilisers, leads to **soil degradation**, increased soil acidification, reduced soil fertility for plant growth, and pollution of water streams and groundwater. Consequently, coffee yields are adversely affected (Le et al. 2021; UNEP 2021; Manson et al. 2022). Prolonged monoculture in coffee farming has been demonstrated to significantly impede the growth of coffee plants and reduce yields by diminishing soil pH, organic matter content, and the richness of soil bacteria and fungi, while simultaneously increasing electrical conductivity (Zhao et al. 2018). It also has a detrimental impact on **biodiversity** (Fernández, Abraham de Jesús Romero et al. 2023).

Waste and wastewater: in cultivation and coffee processing, a **large volume of water** is used for irrigation and for the wet processing of harvested coffee cherries (Martins et al. 2018; Ijanu et al. 2020; Ho et al. 2022). Some coffee cultivation areas are experiencing water scarcity – for example, Minas Gerais and São Paulo (Brazil), (Slater 2019), or the Central Highlands in Vietnam (VietnamPlus 2024). As noted, coffee cultivation requires a substantial amount of water; only approximately 25% of the demand is met by rainfall (Amarasinghe et al. 2015). At present, preliminary estimates indicate that the water consumption for producing one kilogram of green coffee ranges from 8.2 to 29.3 cubic meters, with an average of 18.9 cubic meters, with variations based on regions, coffee species, and cultivation systems (Eriyagama et al. 2014). The projected water footprint for a single cup of coffee is approximately 140 litres in case of the Netherlands, as an example (Chapagain and Hoekstra 2007), with the majority of water being attributed to the cultivation of coffee trees (Martins et al. 2018). The wet-processing system employs a substantial amount of water, averaging around 15–20 litres per one kilogram of

coffee beans, resulting in a significant volume of polluted effluent or **wastewater**. By-products of coffee processing consist of pulp (43%), mucilage (12%), and parchment (6.1%), all of which end up in the wastewater stream. The effluent contains high levels of organic matter and suspended solids and is acidic. Consequently, proper treatment of the wastewater is necessary before discharge into the environment (Ijanu et al. 2020).

Solid waste: the primary contributors include **coffee husks** generated from the processing of cherries using the dry method, bags and sacks discharged after unloading coffee packages, and the waste stream emerging from used coffee capsules or pots. Annually, the coffee industry produces in excess of 10 million tons of coffee waste, which includes husks, pulp, mucilage, silverskins, and spent coffee grounds (Lee et al. 2023b). Coffee husks constitute approximately 12% of the dry cherries by mass (Murthy and Madhava Naidu 2012). For every ton of fresh coffee fruit, around 0.18 tons of husks are generated, and approximately 150 to 200 kg of commercial green beans are produced (Blinová et al. 2017). The husk poses a significant environmental pollution issue because most coffee-processing companies discharge them into the open environment near their sites. The compounds present in coffee husks pose a threat to both health (e.g. respiratory problem, dizziness, eye irritation) and the environment (e.g. from the release of acid, tannins, methane) (Tolessa Amena et al. 2022). **Coffee capsules**, typically composed of around 27% metal and 73% plastic, amounted to a consumption of 48 billion units in 2016. This volume of capsules equates to approximately 576,000 tons of global waste, based on the average weight of a capsule being 12 grams. Unfortunately, this waste stream exhibits low levels of recovery and treatment (Marinello et al. 2021). In addition, most prevalent residues after brewing process in coffee industry are **spent coffee grounds (SCG)**, known for their organic content and acidic characteristics. Typically, one ton of green coffee produces approximately 650 kg of SCG, and each kilogram of soluble coffee produced generates around 2 kg of wet SCG. An estimate indicates a global annual generation of approximately 6 million tons of SCG. The organic compounds within SCG can have various beneficial applications, including the production of biodiesel and activated carbon (Colantoni et al. 2021).

Chemicals: similar to other crops, agrochemicals are employed to manage pests and plant diseases affecting coffee plants. The use of these chemicals has intensified in recent years as farmers seek to boost production and increase profits (Alves dos Santos et al. 2022). For example, Vietnamese farmers use on average 0.6 kg of chemical fertilisers per plant per year, while an optimal application rate of those chemicals is at 0.24 kg per plant per year (Nab and Maslin 2020). Consequently, soil and water become contaminated with these chemicals. Furthermore, the residues of these chemicals in coffee beans may pose health risks to humans due to their toxicity (Alves dos Santos et al. 2022; Merhi et al. 2022).

Energy: coffee stands out as "one of the most energy-intensive food products" (Gosalvitr et al. 2023). According to a European Commission study by Monforti-Ferrario et al. (2015), the embedded energy in the life cycle of coffee is estimated to be around 230 MJ/kg. The processing stage accounts for 33% of the total energy consumption, primarily due to the roasting process occurring at temperatures ranging from 190°C to 245°C (Gosalvitr et al. 2023). Although the brewing (use) stage makes significant contribution to the total energy consumption (Monforti-Ferrario et al. 2015), the energy consumption varies among different methods of preparing coffee (Figueiredo Tavares and Mourad 2020).

Table 3: **Main environmental impacts along the coffee supply chain**

	Cultivation and Harvesting	Processing	Roasting
Water	Substantial volume of water for irrigation	Processing water used for wet processing	
Land use / soil	Deforestation: relocation or expansion of coffee farms Soil degradation, includes erosion, soil compaction or salination, from intensive farming practices: use of agrochemicals and monoculture plantations		
GHG emissions	GHG emissions from deforestation GHG emissions from fertilizer production and application GHG emissions from the transportation of cherries	GHG emissions from energy-intensive processes: drying and/or milling GHG emissions from the transportation of green beans	GHG emissions from energy for roasting and packaging GHG emissions from the transportation and distribution of coffee products
Chemicals	Chemicals used for pest control, chemical fertilisers		
Waste		Wastewater from wet processing Solid waste from dry processing (coffee husks) Packaging waste (bags, sags)	Packaging waste (bags, capsules)

Source: own illustration (adelphi), based on information from Marinello et al. (2021), Barreto Peixoto et a. (2023)

3.2   Sustainable supply chain management approaches and instruments used in the coffee supply chain

There have been various sustainable supply chain management (SSCM) approaches and tools used to address these impacts. They can be **individual or collective approaches**, in which, in the coffee sector, most are **voluntary** and initiated by **buyers**. Many of them can be categorised as **supply chain collective approaches** as they involve different stakeholders and require collaboration to succeed. Or, in other words, they reflect the collaboration strategies among supply chain actors. The classification of an approach as collective, individual, or supply chain-oriented depends on the assessment and applications. For instance, certification encourages collective adherence to social, environmental, and ethical standards and involves collaboration among producers, processors, and distributors to ensure fair compensation, environmentally friendly practices, and sustainable agriculture. However, certification can be seen as an individual voluntary approach for coffee suppliers and buyers. The adoption of technology involves individual companies investing in advanced supply chain management technologies like blockchain for traceability, which amounts to an individual, voluntary approach. However, when these technologies are integrated into a platform, like a supply chain transparency or traceability platform, it transforms into a collective approach.

Audits and certification: audit and certification schemes, including ISO 9001, ISO 14001, Fairtrade, Rainforest Alliance, and Organic, serve various purposes. The certification programmes involve collaboration among producers, processors, and distributors to ensure fair compensation, environmentally friendly practices, and sustainable agriculture (**supply chain collective voluntary approach**). They may certify a company's adherence to international standards set by the International Organisation for Standardisation (ISO), endorse farming practices that promote sustainable development, or consider the protection of ecosystems and biodiversity (**buyer- / supplier-individual voluntary approach**). These certifications have been utilised as marketing tools for products, addressing competition and public scrutiny. Consumers often view certified products as safe and environmentally friendly. Sustainability certification schemes aim to assist coffee farmers in maintaining high yields while production costs and environmental degradation can be reduced. This is achieved through educational initiatives on optimal use of fertiliser, energy, and water. Some certificates, like Fairtrade, guarantee a **price premium**. The combination of lower production cost and price premium has been identified as bringing more profits to sustainable coffee agriculture than conventional methods. However, there are limitations, such as difficulties in monitoring certain criteria, a lack of specific requirements for local context to uphold environment and biodiversity protection, overestimation in coffee quantity, or posing a barrier for new producers who have not yet obtained certification (Schmidt et al. 2019; Nab and Maslin 2020).

Companies like Starbucks (2024), Tchibo (2023b) and others deploy **codes of conduct** to align their supply chains with sustainable and ethical practices. Codes of conduct are sets of rules and standards that suppliers in the coffee supply chain are expected to follow to maintain business relationships. These typically cover aspects such as environmental management, social responsibility, and economic practices. Third party certificates also include many codes of conducts. For example, the 4C Code of Conduct (4C Services GmbH 2024) focuses on sustainable production of coffee green bean and post-harvest activities.

Buyers conduct **audits of new suppliers** as essential tools for verifying that suppliers comply with the established codes of conduct. They involve evaluating potential suppliers on their practices and infrastructure, **regular audits** to conduct scheduled checks their suppliers for ongoing compliance, and **corrective actions** to implement necessary changes when

discrepancies or violations are found. As a last resort, if suppliers fail to correct their actions, the contract may be terminated. Given the power buyers hold over suppliers, they can impose third-party-verified certifications and codes of conduct that include mandatory certification requirements, frequent audits, required data reporting, and transparency demands. These instruments are part of coercion strategies. While these strategies ensure compliance with sustainability and ethical standards, they can also place significant financial and administrative burdens on suppliers, particularly smallholder farmers.

Farmer cooperatives (**supplier collective voluntary approach**): many coffee-producing regions, such as Ethiopia and Brazil, have established farmer cooperatives where individual growers join forces to collectively negotiate prices, access resources, and share knowledge. These cooperatives empower small-scale farmers and enhance their bargaining power in the supply chain to a certain extent (see also Chapter 3.4 of Strasser et al. 2024 for more information).

Price premium (**buyer individual voluntary approach**): obtaining certification involves the payment of inspection fees, with some cooperatives and supply chain partners able to bear the economic cost, while, in many cases, it falls on the farmers. This cost burden has the potential to limit farmer participation ability. Moreover, following certification principles and standards may result in lower yields while farmers need to cope with higher operational costs, especially when price premiums are not factored in. The profitability of adhering to sustainable standards and certifications depends on the existence of a demand willing to pay a price premium that compensates farmers for their efforts and the costs associated with altering their production systems (Gatti et al. 2022). From the perspective of international roasters, there is a tendency to pay a price premium for certified coffee. For instance, Nespresso pays an average of 30-40% more for green coffee and 10-15% more for specialty coffees compared to market prices from coffee farmed under sustainable principles (Nespresso 2023b). Consumers also express willingness to pay a premium. In Germany, consumers express their willingness to pay 68% more for carbon neutral-certified coffee over uncertified coffee (Birkenberg et al. 2021). In the United States, a price premium of 27% for organic certified coffee was paid by consumers (van Loo et al. 2015). They expressed a readiness to pay an additional $2.20 per 12 oz (or 0.34 kg) for Bird Friendly coffee in comparison to conventional coffee. The premium prices for certified coffee are not the same; for example, organic coffee was bought at the highest premium at $5.80 per 12 oz, followed by pesticide-free coffee at $3.60, and shade-grown coffee at a lower premium of $1.40 (Gatti et al. 2022).

Traceability tools: traceability has the potential to gain competitive advantages, enhancing operational efficiencies, reducing costs, boosting productivity, securing reputational benefits, and improving environmental performance throughout the coffee supply chain (**supply chain collective voluntary approach**) (León-Bravo et al. 2022). The ongoing discussion is about whether Traceability Systems (TS) are primarily driven by quality or sustainability performance targets – or by the desire to gain recognition and acceptance in consumer markets. TSs can take on various forms, ranging from simple approaches like including product information on packaging or adhering to the Hazard Analysis and Critical Control Points (HACCP) standard, or to more advanced methods such as purchases of certified coffee (e.g. organic and fair trade). Some companies also adopt integrated systems, like blockchain or real-time monitoring. Companies deploy varied TSs based on their capabilities and interests to achieve multiple benefits, including sustainability (**buyer individual voluntary approach**). However, traceability and sustainability are not always managed together, as sustainability is often driven by a company's values and commitment (León-Bravo et al. 2022). The implementation cost of traceability remains a significant barrier, requiring substantial technology and process

investments. These features prove useful in addressing operational challenges across various supply chains. Additionally, blockchain supports "**smart contracts**", i.e. computer programmes that automate transactions when predetermined conditions are satisfied (Bettín-Díaz et al. 2022). A noteworthy traceability development in recent years is the emphasis on the origin of coffee. Farmers are leveraging their geographical location to safeguard the reputation and increase the value of their single-origin coffee. This trend presents a new market opportunity by providing consumers with credibility and offering economic advancement for farmers (Sepúlveda et al. 2016).

Sustainable Supply Chain Finance (**supply chain collective voluntary approach**): Supply Chain Finance (SCF) comprises a set of solutions designed to enhance the optimisation and balance working capital within supply chains by leveraging the relationships between buyers and suppliers. These SCF solutions can be deployed to provide financial support to suppliers in need and contribute to supply chain sustainability – in this way, SCF has the potential to serve as an instrument for promoting and disseminating sustainability practices in the supply chains. The Sustainable Supply Chain Finance (SSCF) involve various activities, including financing schemes or trade credit solutions. They act as a means for buyers to enhance the sustainable performance of their suppliers and overall supply chain sustainability. For instance, financing schemes may be implemented wherein the buyer, in collaboration with a financial institution, extends financing at favourable interest rates or offers technical assistance to suppliers engaged in sustainability practices. This support aims to assist suppliers in improving their sustainability performance, with financial incentives provided by the buyer serving as incentives for suppliers (Medina et al. 2023). A number of funding sources under SSCF includes Green Climate Fund (GCF), which uses "a flexible combination of grant, concessional debt, guarantees or equity instruments", to "support developing countries raise and realise their Nationally Determined Contributions (NDC) ambitions towards low-emissions, climate-resilient pathways" (GCF 2023); Coffee Innovation Fund, which is financed by the German Federal Ministry for Economic Cooperation and Development (BMZ), aims to support "pioneering projects that make coffee cultivation more profitable for farmers in innovative ways" (INA 2019). Brands also lead some initiatives linked to SSCF. For example, Coca-Cola Europacific Partners (CCEP), in collaboration with Rabobank, implements a new sustainability supply chain finance programme (CCEP 2022) and coffee was identified as one among 13 priority ingredients and bio-based packaging materials. Another instance is the Starbucks Global Farmer Fund, which extends financial support to coffee farmers through loans for initiatives related to restoration, improvements of agronomy and infrastructure (Starbucks 2023).

Smart contracts (Buyer individual voluntary approach): built upon blockchain technology and Internet of Things (IoT) devices, smart contracts have been developed in the coffee supply chain through various projects. One example is the work of Ramachandra et al. (2023), which seeks to address multiple risks and challenges in the coffee supply chain, including issues related to inadequate storage and transportation facilities, fraud, and data manipulation in coffee trade. The aim is to enhance trading transparency by leveraging advanced technologies. Another instance involves the development and utilisation of a smart contract by Cristian et al. (2022) for monitoring the transportation and storage status of coffee, with data verification mechanisms in place. In essence, smart contracts offer various advantages. They contribute to economic benefits through the deployment of reliable, standardised, fast, and automatically executed transactions, and supporting the reduction of transaction costs. However, the primary components of blockchain infrastructure, including data centres for computation, data storage and transmission, and the creation of smart contracts, land use for data centres, among others, constitute a substantial portion of the overall costs. Smart contracts play a role in promoting sustainability within the supply chain by enabling the verification of pre-defined quality

standards or environmental conditions for transaction approval. Nevertheless, the energy consumption associated with the operation of blockchain technology systems contributes to greenhouse gas emissions, presenting a complex and contradictory relationship between smart contracts and environmental sustainability (Groschopf et al. 2021b).

Company initiatives (buyer individual voluntary approach): some companies take the initiative to implement sustainability practices within their operations. This may include adopting eco-friendly packaging, reducing carbon emissions, or implementing fair labour practices. These efforts contribute to the company's overall commitment to social and environmental responsibility. Some prominent coffee roasters have established their own private certification initiatives. Starbucks, through its Coffee and Farmer Equity (C.A.F.E.) Practices (Starbucks 2020), and Nespresso, with the Nespresso AAA Sustainable Quality™ Program (Nespresso 2023a), have introduced proprietary standards. These standards primarily focus on aspects such as quality, productivity, and sustainable coffee, encompassing economic transparency, social responsibility, and environmental protection. As highlighted in the preceding section, multinational companies within the global coffee supply chain also offer financial initiatives to assist coffee growers. Furthermore, there are other **sectoral initiatives** (**supply chain collective voluntary or supplier collective voluntary approach**) like the Global Coffee Platform (GCP) (GCP 2023), functioning as a multi-stakeholder membership association, and the International Coffee Organisation (ICO) (ICO 2023), serving as an intergovernmental organisation dedicated to advancing sustainability across global coffee value chains.

Educational and training programmes (supply chain collective voluntary approach): collaborative initiatives focused on providing education and training to coffee farmers contribute to improved crop management, sustainable farming practices, and increased productivity. These programmes are often conducted in partnership with NGOs, governments, and industry stakeholders. When they are a part of company initiatives, they might be considered as a **buyer collective voluntary approach**. When suppliers are required to participate in training programmes organised by buyers to ensure they understand and implement the required standards or receive technical assistance offered by buyers, they can serve as a form of coercion strategy if participation is mandatory and linked to the continuation of business relationships.

Climate resilience initiatives (**supply chain collective voluntary approach**): with climate change impacting coffee-growing regions, collective efforts underway to address these challenges. Collaboration involves implementing climate-smart agricultural practices, developing drought-resistant varieties, and sharing resources to build resilience against climate-related risks. Examples of climate resilience initiatives include agroforestry practices (Wienhold and Goulao 2023), diversification in coffee farming (Fadah and Prihandono 2019), and more (water conservation and management, soil management, education and training). If these activities are initiatives in the part of buyers, they can be categorised as representing a **buyer collective voluntary approach**.

Responsible contracting and sustainable sourcing practices (**buyer collective voluntary approach**): the significance of responsible contracting is emphasised for sustainable participants in the supply chain. Companies uphold responsible contracting practices through the implementation of responsible contract policies, agreements, or other instruments related to responsible supply chain operations with enforcement mechanisms (NELP 2017). Critically, the shift towards sustainable sourcing by buyers, as seen in changes to their selection practices, can reshape the dynamics between procurement and sustainability. This transformation influences sourcing criteria and how buyers assess the performance of their suppliers, often facilitated

through mechanisms like supplier codes (Cafaggi 2016). International brands, such as Tchibo (Tchibo 2023a), Starbucks (Starbucks 2023), or Jacobs Douwe Egberts (JDE 2021), have underlined responsible sourcing principles that encompass various sustainability aspects, including land protection, equality, livelihood improvement for farmers, coffee quality, among others.

Direct sourcing (**buyer individual voluntary approach**): companies may choose to directly source coffee beans from specific farms or regions either with or without the Direct Trade label. Direct Trade is an uncertified label indicating a method where coffee roasters directly engage with farmers to negotiate both the price and quality of the coffee, bypassing intermediaries; the process aims to increase income for farmers (Gerard et al. 2019; Direct Trade 2024). This approach allows for closer relationships with coffee producers, quality control, and the ability to establish unique supply agreements that meet the company's specific requirements.

Integrated supply networks (**supply chain collective voluntary approach**): the integration of supply networks involves the sharing of information and resources, collaboration, and organisational linkages among suppliers and purchasers as members. In the coffee industry, increased integration has been observed at regional and national levels, as evidenced by studies in Peru (Ramos et al. 2023), Seka Chekorsa, Ethiopia (Gemechu et al. 2020) and Indonesia, which focuses on digitalisation integration as demonstrated in the study by (Tseng et al. 2022). The advantages of supply network integration include the creation of market competitiveness, increased business profits, total cost reduction, and the development of sustainable customer satisfaction (Gemechu et al. 2020). Furthermore, it enhances accessibility to labour conditions, supply chain finance, and social responsibility (Tseng et al. 2022). Supply network integration has also demonstrated positive effects in responding to crises, such as the COVID-19 pandemic, ensuring higher performance for the coffee supply chain compared to high levels of supply chain agility (Ramos et al. 2023). Some companies in the coffee sector, such as Starbucks (Modum 2020), opt for **vertical integration** by owning and controlling various stages of the supply chain, from coffee plantations to processing facilities and distribution. This can provide greater control over quality, efficiency, and cost.

Circular business models (**supply chain collective voluntary approach**): in a circular economy in the coffee supply chain, resources and materials are maximally utilised through processes of reduce, reuse, recycling, and composting. Circular economy approaches play a pivotal role in facilitating the transition to a sustainable coffee supply chain. Within this framework, circular business models offer solutions to reduce waste and enhance resource efficiency in coffee production (e.g. water efficiency, adoption of organic farming practices, improved harvesting techniques, and regenerative farming practices) and coffee processing (incorporating renewable energy, reusing coffee by-products, recycling packaging, and utilising biodegradable coffee capsules). Other initiatives include implementing take-back systems for coffee packaging, among other measures. Numerous studies showcase instances of reusing coffee by-products, such as ethanol production through the fermentation of coffee husks and pulp, gasification of dry coffee husks, and the cultivation of mushrooms (Lagrasta et al. 2021). Other initiatives involve the production and distribution of coffee cups with the capacity to collect and recover aluminium shells while composting the coffee waste from the cup washing step (Aarikka-Stenroos et al. 2022). There are many other innovative practices.

Government enforced compulsory and collective approaches, such as EUDR (as mentioned in Interim Report 1) and Germany's Act on Corporate Due Diligence Obligations in Supply Chains impact SSCM within the coffee sector. EUDR focuses on curbing deforestation-related imports, compelling the coffee industry to adopt responsible-sourcing practices that prioritise environmental conservation. The German law mandates companies to identify and address

human rights and environmental risks in their supply chains, thereby promoting a holistic approach to sustainability in the coffee sector. These regulations collectively encourage transparency, ethical sourcing, and responsible business conduct throughout the entire coffee supply chain. The costs related to compliance with these regulations are borne by actors in the supply chain. The distribution of costs among stakeholders can vary depending on the specific regulations, industry practices, and market dynamics. In many cases, there is a growing recognition of the shared responsibility for sustainable and ethical practices throughout the supply chain. Collaborative efforts and partnerships between stakeholders are essential to address challenges and ensure the effective implementation of regulations without unduly burdening any particular segment of the supply chain.

The approaches and tools employed for SSCM in the coffee sector contribute to various degrees of improvement in environmental sustainability. These approaches are inherently associated with both advantages and disadvantages/costs for both buyers and suppliers.

Generally, approaches and instruments that promote transparency, fair pricing, and collaboration between suppliers and buyers create a win-win situation for both parties in the coffee supply chain. In other words, most instruments bring advantages to both buyers and suppliers. However, the perception of advantages may vary when viewed from the perspectives of buyers or suppliers, considering factors such as bargaining power or initiation of instruments. As seen from Figure 8, farmer cooperatives clearly bring more advantages for coffee farmers (suppliers) through improving their bargaining powers, improving market access, and supporting shared resources and expertise, but they also offer advantages for buyers through consistent quality and supply, traceability and ethical sourcing. The same assessment can be applied for price premium, circular business models, climate resilient initiatives, educational and training programmes, sustainable supply chain finance, and certificates (e.g. ISO 9001, ISO 14001, Rainforest Alliance, organic). When evaluating other instruments, for example, direct sourcing, company initiatives, certifications (e.g. ISO 9001, ISO 14001), traceability tools, smart contract, responsible contracting and sustainable sourcing, integrated supply network, tend to favour buyers with more advantages. The government enforced compulsory and collective approaches are considered to offer equal advantages for both suppliers and buyers.

Placing the described business approaches and instruments in the coffee supply chain in a matrix based on the definition of (perceived) distributional fairness (advantage for supplier/advantage for buyer) and approach to influence the desirability of the requested changes for the business partner (incentivising/penalising) presented in this chapter, the following pattern emerges.

Figure 8:   **Matrix of instruments and approaches in the coffee supply chain**
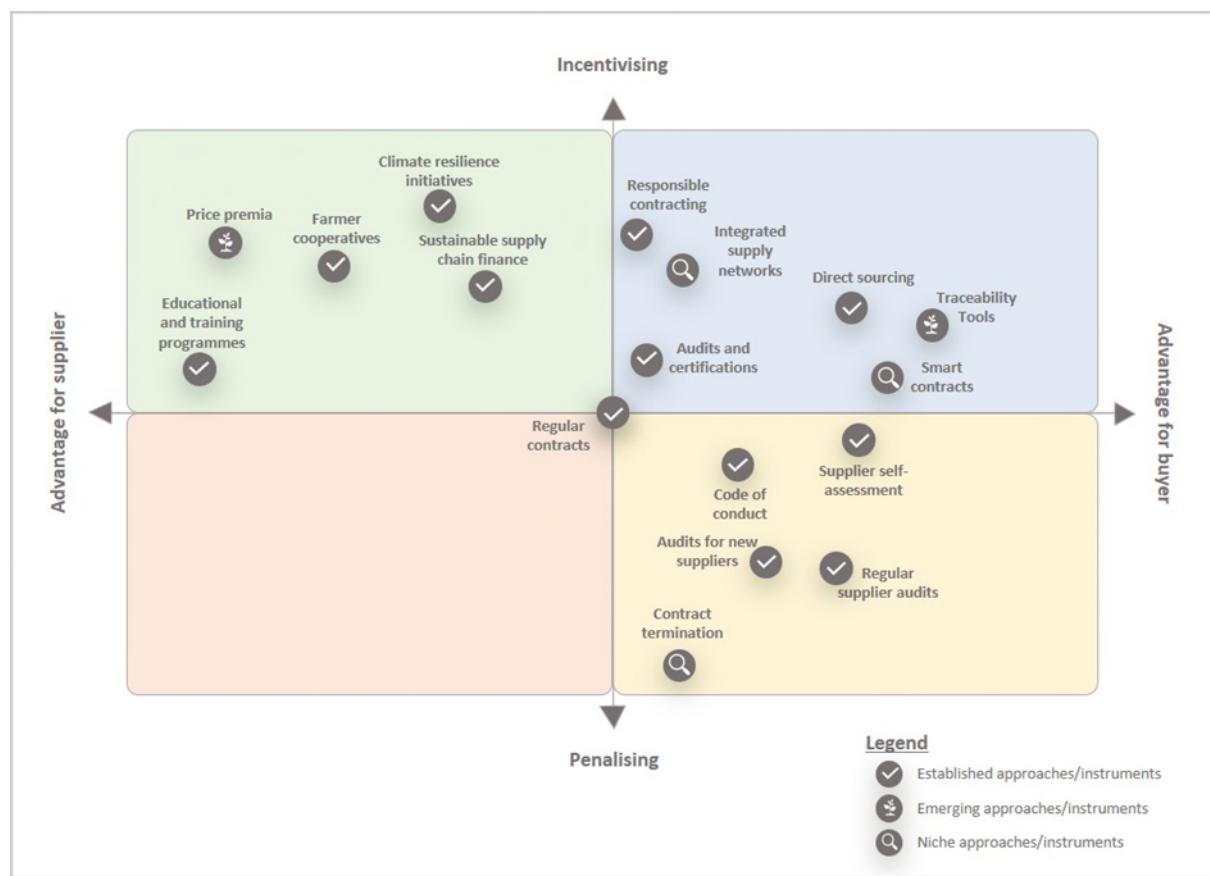
Source: own illustration (adelphi).

As shown in Figure 8, traditional, penalty-based approaches in supply chains are perceived to favour buyers, while newer approaches that emphasise incentives and rewards are seen as more beneficial for suppliers. A variety of instruments and approaches are used within supply chains. Some are well-established practices; others are considered as emerging instruments, such as price premia, or traceability tools that might be driven by recent regulatory requirements. Others, like smart contracts and contract termination, are less commonly used. This analysis can help identify promising approaches and instruments that warrant further investigation for potential wider adoption.

4   Roadmap for the coffee supply chain

This chapter is an excerpt of the report "Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains - Roadmaps for the implementation of sustainable supply chain management approaches and instruments" (Grüning et al. 2025). It presents an exemplary roadmap for the implementation of supply chain management instruments to improve the cost-benefit sharing and sharing of environmental information in the coffee supply chain. The roadmap can assist companies in the sector and other stakeholders in advancing the environmental performance of suppliers and sub-suppliers primarily through incentives and cooperation. The roadmap includes a description of the environmental upgrading target, tailored sustainable supply chain management instruments, key actors for implementation, interactions between the instruments, and necessary framework conditions.

4.1   Environmental target and background

This roadmap is intended as a strategic guide for companies in the coffee industry, focusing on enhancing sustainability by addressing deforestation, a critical environmental challenge due to its significant impact on climate change and ecosystem degradation. While deforestation is the primary focus, it should be acknowledged that there are other important environmental impacts in the coffee value chain not addressed here, such as water use, waste management and pollution, among others. The emphasis on deforestation is driven by the need to comply with the EU Regulation on Deforestation-free Products (EU Deforestation Regulation – EUDR). Compliance with the EUDR is crucial for meeting legal requirements and for positioning the industry in environmental stewardship.

Between 1990 and 2020, global deforestation resulted in the loss of approximately 420 million hectares of forest (FAO 2020). Coffee production is recognised as a significant contributor to this deforestation, with forest loss estimated at 130,000 hectares per year over the past twenty years (Panhuysen and Pierrot 2020). As global demand for coffee continues to rise, the expansion of coffee farms often links to the destruction of forests. The expansion not only leads to habitat destruction and a decline in biodiversity, but also intensifies climate change by releasing carbon stored in forests and diminishing the planet's capacity to absorb greenhouse gases (Giam 2017; Panhuysen and Pierrot 2020; UN 2022; Faria et al. 2023; Pfenning-Butterworth et al. 2024; Weiskopf et al. 2024).

Moreover, deforestation disrupts hydrological cycles, altering precipitation patterns and water availability (Ellison et al. 2017; Dhaliwal 2023). The removal of forest cover also leads to increased soil erosion and degradation, reducing soil fertility (Samec et al. 2022). The magnitude of these impacts highlights the critical need to tackle deforestation within coffee supply chains aiming not only for environmental sustainability but also for ensuring the long-term viability of the coffee industry itself.

At the global level, initiatives like the United Nations' REDD+ (Reducing Emissions from Deforestation and Forest Degradation) (UN-REDD Programme 2016) provide a framework for valuing forests' carbon storage capacity and incentivising forest conservation. The EU has taken a leading role with the introduction of the EUDR, which came into force on 29 June 2023. The EUDR significantly impacts the coffee supply chain (as one among other commodities, such as cattle, wood, cocoa, soy, palm oil, and rubber) by requiring that coffee imported into or exported from the EU must be produced on land that has not been subject to deforestation after 31 December 2020.

The EUDR mandates strict due diligence processes, compelling coffee companies to provide comprehensive traceability and sustainability documentation. This regulation aims to leverage the EU's market power to reduce global deforestation, thereby reshaping the coffee industry's approach to environmental sustainability and supply chain management (EC 2023a; EC 2023b). Consequently, coffee producers, traders, and retailers must adapt their practices to ensure compliance, potentially leading to changes in sourcing strategies, increased costs, and a shift towards more sustainable production methods. In other words, the EUDR is expected to significantly reshape market dynamics, potentially also favouring larger, more organised producers who can more easily comply with traceability requirements, and more of a producers' environment, such as local infrastructure, market access. At the national level, countries are responding differently. For instance, Brazil has implemented strict forest monitoring systems, while countries like Vietnam and Uganda are proactively working on national traceability systems to comply with the EUDR (Quynh Chi and Meulensteen 2023).

Many coffee roasters, particularly those with a significant presence in the EU market, have proactively responded to the EUDR, recognising the critical environmental impacts of coffee production, especially concerning deforestation. In light of these regulatory requirements and industry efforts, the goal is to ensure that 100% of coffee products sold in the EU market are deforestation-free. Taking into account the postponement of the application of the EUDR, the following target was defined on this basis:

Environmental upgrade target – coffee (large companies)

By 30 December 2025, 100% of coffee products sold in the EU market are deforestation-free.

Environmental upgrade target – coffee (small and medium sized companies)

By 30 June 2026, 100% of coffee products sold in the EU market are deforestation-free.

According to information gathered through interviews and expert contributions from some coffee companies, current coffee sourcing practices normally involve a mix of direct purchases from farmers and acquisitions through intermediary traders. This approach allows companies to leverage established trade networks while maintaining direct relationships with coffee growers, particularly small-scale farmers. To ensure supply chain resilience, these companies source from a geographically diverse base, including regions in Asia, America, and Africa. Additionally, a portion of the coffee beans are certified by organisations such as Fairtrade, Rainforest Alliance, or Organic, further supporting sustainable and ethical production practices.

In pursuit of deforestation-free targets, a comprehensive network of actors throughout coffee supply chain needs to be involved. This network encompasses many actors – including coffee companies (roasters, EU importers and exporters), farmers, intermediaries (traders or intermediaries), local governments, NGOs, consumers, external auditors, and certification bodies. Within larger coffee company, various key internal departments, including finance, information technology (IT), procurement, legal, marketing, quality assurance and sustainability can take part by providing specialised knowledge in environmental issues and sustainable practices. Additionally, representatives from the management board can ensure alignment with the overall company strategy and facilitate high-level decision-making. By integrating these diverse perspectives, the efforts will be well-positioned to drive the company's sustainability agenda forward, ensuring that deforestation-free initiatives are seamlessly integrated across all aspects of the business operations. Many coffee companies have implemented regular activities to support coffee farmers in supply countries, such as training programmes on sustainable cultivation practices, coffee certification programmes for strategic farmers, joining MSIs such as

the Coffee Public-Private Task Force by the International Coffee Organisation (ICO 2023), World Coffee Research aiming at developing more climate resilient varieties (World Coffee Research 2024), or stronger alignment between sustainability programmes and procurement practices.

Implementing deforestation-free practices in the coffee industry has revealed several significant challenges. The predominance of smallholder farmers coping with inadequate levels of infrastructure and low traceability in some countries makes implementing and monitoring anti-deforestation measures complex and costly (Sjoerd Panhuysen and Frederik de Vries 2023). Coffee production varies significantly across producing countries, with small producers, especially those not organised in cooperatives or associations, being the most vulnerable. Their coffee, often sold to intermediaries and mixed, poses traceability challenges (Charles 2024). While importers bear legal liability for EUDR compliance, the burden of data gathering falls heavily on producers. Small coffee farmers may struggle to provide the required geodata, potentially leading to their exclusion from the EU market due to lack of data rather than actual deforestation practices. This situation may force farmers to shift sales to non-EU countries, contradicting the regulation's goal of reducing deforestation risk (International Coffee Partners 2024). As a result, there are questions that must be asked, namely who bears the cost/burden of collecting farm-level data, who can scale up such data gathering, and who ensures data quality, including across time. Intermediary (midstream) actors are crucial in data collection and sharing, but integrating their databases with other digital systems presents unresolved technical challenges. They may favour easily traceable farmers and exclude others, potentially making the roasters' final supply less inclusive and less diversified. Under EUDR, roasters must conduct risk analyses, but some traders withhold crucial information, e.g. geocoordinates. This reluctance stems partly from concerns about conflicting assessments between traders and roasters. Moreover, the process of data verification for the EUDR Regulatory Platform has led to duplicated efforts and overlapping data sets, further complicating compliance (Fanarioti and Pirola 2024).

Economic pressures, including price volatility and increased production costs (due to increasing input costs), prevent coffee farmers from implementing sustainability practices and investments that help them to improve their income in the long term (Fairtrade International 2023). Climate change is projected to render significant portions of current coffee-growing lands unsuitable by 2050, particularly for Arabica coffee, potentially exacerbating existing challenges for farmers. Consequently, there might be the need for them to expand production to maintain income, which can drive further deforestation (Bunn et al. 2015). The complexity of supply chains, with multiple intermediaries between farmers and exporters, further complicates traceability efforts (Grabs and Carodenuto 2021).

4.2   Description of the roadmap

The following roadmap is based on the results of research, findings from workshops and interviews with industry experts from business, civil society, research institutions, etc., and insights shared by experts from coffee companies. The roadmap does not entail all possible SSCM instruments that companies could apply in the coffee supply chain, but only those identified as the most impactful for deforestation. This multifaceted approach aims to prevent the unintended consequence of shifting deforestation issues to other locations – a potential risk associated with the EUDR. It should be noted that, this roadmap assumes that the company applying the SSCM instruments operates as a coffee roaster, importer, and/or exporter, serving markets within the EU.

Figure 9 presents a roadmap with a combination of different instruments (audit and certification process, extensive stakeholder collaboration, data management and traceability, education and

training for farmers, responsible contracting, and price premiums) initiated by individual companies (usually buyers) for enhancing environmental performance with focusing to achieve deforestation-free in the coffee supply chain. The implementation of the instruments covers a timeframe of approximately two years to achieve the mentioned environmental target, taking into account the postponement of the application of the EUDR until 30 December 2025 and for 30 June 2026 for small and medium sized companies. However, the timeline can be considered applicable for other companies when aiming for achievement deforestation-free in their supply chain. The roadmap illustrates a timeline with different instruments divided into three categories (third-party, supply chain-collective, and buyer-initiated) and their implementation periods. These instruments are designed to be implemented concurrently and span the entire time period. This means that while they may have different starting points, they require on-going activities to further adapt and monitor their effectiveness. While all instruments can be initiated promptly, certain ones, like 'extensive stakeholder collaboration' and 'data management' and 'traceability', can commence immediately. Once these instruments are established, others can follow. The initiation of each instrument also depends on available resources, for example, company personnel, experience, and knowledge of the instrument.

Each instrument and action for the respective actors will be explained in detail between 4.2.1 and 4.2.6.

Figure 9:   **Roadmap for improved environmental performance in the coffee supply chain**
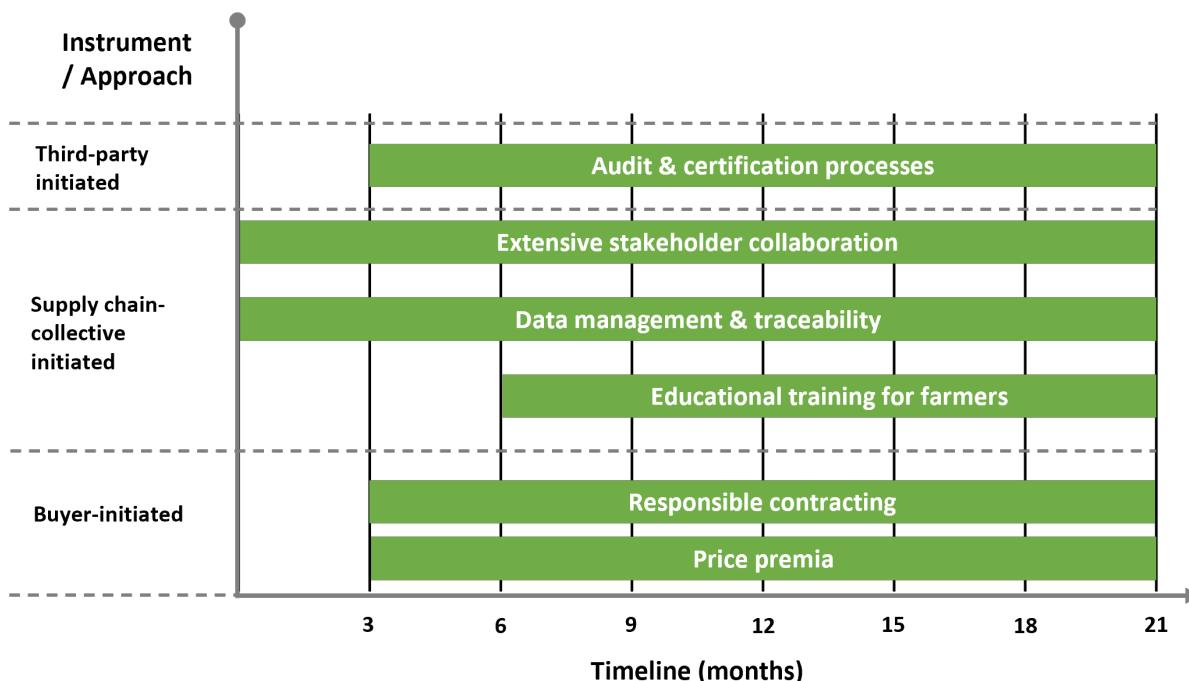
Source: own illustration (adelphi research gGmbH)

4.2.1   Instrument 1: Extensive stakeholder collaboration

Achieving deforestation-free coffee production is a complex challenge that requires the coordinated efforts of multiple stakeholders across the entire supply chain. All actors, including companies (and their relevant internal departments), farmers, suppliers, NGOs, local governments, and other industry partners are part of this instrument. Effective collaboration among these diverse groups is crucial for developing and implementing successful sustainability strategies, particularly in the context of complying with the EUDR.

This instrument aims at creating a unified approach to achieving deforestation-free targets, leveraging diverse expertise and resources for innovative solutions, ensuring alignment of sustainability efforts across the supply chain, enhancing transparency and trust among all stakeholders, facilitating knowledge sharing and best practice dissemination, and addressing systemic challenges that require collective action.

Involved key stakeholders and their roles are provided in Table 4:

Table 4:   Key actors and actions for implementing extensive stakeholder collaboration

Key Actors	Actions for Implementation
Company	- Highlight the importance of collaboration (such as partnerships with farmers and cooperatives, collaboration with sustainability initiatives) and allocate resources, and participate in high-level stakeholder forums (management board). - Coordinate overall stakeholder engagement strategy and facilitate connections between different stakeholder groups (sustainability team).
Farmers and Intermediaries	- Provide ground-level insights on challenges and potential solutions and participate in collaborative initiatives and feedback processes.
NGOs and relevant organisations	- Offer expertise on deforestation issues and conservation strategies (such as shade-grown coffee initiatives, water management, climate-smart coffee farming) and collaborate on community-based sustainability projects.
Local Governments	- Support for company efforts by creating enabling environment for sustainability initiatives and develop policies and action plans for sustainability in their jurisdictions.
Industry Partners	- Collaborate on sector-wide sustainability initiatives and share knowledge and resources for collective impact
Research Institutions	- Provide scientific insights and innovative approaches and conduct studies on the effectiveness of sustainability measures
Consumers	- Provide feedback on sustainability initiatives and participate in awareness and behaviour change campaigns

Efforts to join collaboration platforms (e.g. ICO, Specialty Coffee Association) for on-going engagement and budget allocation for stakeholder meetings and projects are required. Effective communication tools ensure regular updates and transparency. Key levers focus on building trust through transparency, showcasing the benefits of collaboration, leveraging stakeholders' unique strengths, and maintaining open communication. It is expected that the traceability will be improved, relationships among different actors can be enhanced, implementation risks can be reduced, among other things.

This instrument is fundamental to the success of all other instruments, including traceability systems, responsible contracting, price premiums, educational programmes, and audit and certification.

4.2.2 Instrument 2: Enhanced data management and traceability systems

The complex supply chain, involving numerous smallholder farmers and intermediaries, presents significant traceability challenges. The EUDR mandates comprehensive documentation and traceability, making this a critical issue for compliance and sustainability efforts.

End-to-end traceability from individual farms to the final consumer product needs to be in place. Enhanced data management and traceability systems aim to verify the deforestation-free status of all coffee sources, ensure EUDR compliance, provide transparency, enable quick identification and resolution of sustainability issues, and support fair pricing. The system should track key data points such as farm location (including geolocation data), farming practices, harvest dates, processing methods, and transportation routes.

Key actors and their roles are provided in Table 5:

Table 5:   **Key actors and actions for implementing enhanced data management and traceability systems**

Key Actors	Actions for Implementation
Company	- Design and develop their traceability system and data collection solutions (in-house solutions), or utilise third-party solutions (such as Global Coffee Data Standard for data collection (Meems 2019), Dimitra, INATrace, Sourcemap (Pirola and Criscione 2024)), ensure security and data protection (IT team, Sustainability team. Define traceability requirements, oversee implementation and integration with existing processes, and clarify data points for EUDR compliance, review data regularly (Sustainability team).
Farmers Intermediaries	- Provide accurate data, participate in system design consultations, attend training, and use the system regularly.
External technical providers	- Supply necessary technology, provide technical expertise and on-going support.
Consulting firm/expert or research institution	- Develop multilingual training materials, conduct training sessions, provide on-going support.

To implement traceability systems, the company, as the initiator, will likely cover the majority of the investment cost in technology infrastructure, develop data collection tools, leverage technical expertise, create multilingual training materials, and deploy on-ground support staff in coffee-growing regions. It is also possible that the company might seek financing from industry partners or government. Producers might bear some of the costs of implementing and maintaining new traceability systems through various means. However, in the long term, these costs may be compensated through price premiums, long-term contracts, access to new markets, efficiency gains, shared value programmes, microfinancing, and gradual implementation. To ensure long-term sustainability and the equitable distribution of costs and benefits, the company should collaborate closely with producers, understanding their financial constraints and developing mutually beneficial solutions. Success is ensured by user-friendly technology suitable for low-connectivity areas, clear demonstration of benefits to actors, incentives for accurate data input, and a commitment to continuous support and training.

This system forms the foundation for other instruments, supporting audit and certification processes, responsible contracting, training programmes and stakeholder collaboration.

4.2.3   Instrument 3: Responsible contracting

The actors in the coffee supply chain need to demonstrate due diligence in preventing deforestation, necessitating clear contractual obligations with all suppliers. Additionally, recognising that the burden of compliance with sustainability standards and regulations, including the EUDR, often falls disproportionately on producers, particularly smallholder farmers; a shared responsibility approach is necessary to address this imbalance. This instrument aims to create a legally binding framework for sustainability, ensuring all suppliers, including intermediaries, commit to deforestation-free practices. Creating a mutual agreement, which is based on an equal partnership that defines responsible practices, including labour standards, business conditions, payment terms, and the buyer's commitments regarding purchasing behaviour is considered crucial (Ethical Trading Initiative 2024). Shared responsibility supports the distribution of the costs and efforts of EUDR compliance more evenly, particularly supporting smaller suppliers and farmers. Ultimately, this instrument aims to increase engagement from all stakeholders, improve sustainability outcomes through collaborative efforts, and align incentives for deforestation-free coffee production throughout the supply chain. It also establishes clear accountability for sustainable practices and provides a basis for on-going monitoring and improvement as regards deforestation-free practices.

Key actors and their roles are provided in Table 6:

Table 6:   **Key actors and actions for implementing responsible contracting**

Key Actors	Actions for Implementation
Company	- Establish overarching principles for shared responsibility and allocate resources for implementation and support mechanisms (management board). - Review existing contracts, draft new clauses addressing deforestation and sustainability based on principles of shared responsibility and equal partnership, ensure compliance with international and local laws (legal team). - Communicate new requirements to suppliers, negotiate terms, and manage the contract update process, integrate shared responsibility principles into supplier relationships, and collaborate on developing support mechanisms for suppliers (procurement department). - Develop clear, measurable sustainability criteria for inclusion in contracts, provide expertise on deforestation issues, develop detailed actions for shared responsibility, and coordinate implementation across departments and with external partners (sustainability team). - Develop and implement models for fair cost-sharing across the supply chain and allocate funds for support mechanisms and collaborative initiatives (finance department).

Key Actors	Actions for Implementation
Intermediaries	- Review existing contracts, contribute and agree to new contract terms from their buyers. Review existing contracts with suppliers and integrate deforestation and sustainability aspects into the new contract terms based on principles of shared responsibility and equal partnership. - Provide necessary data and documentation.
Farmers	- Review, contribute and agree to new contract terms, implement required practices, provide necessary data and documentation.
External legal advisors (if needed)	- Provide expertise on international environmental law and trade regulations.

To ensure success of this instrument, clear communication of benefits and requirements to all actors is required. A phased implementation approach is required for adaptation, incorporation of potential incentives (such as price premium, long-term contract, marketing support, access to the training) and early adopters of new standards. This approach also allows on-going support for suppliers (such as technical assistance, training programme, financing support, gradual implementation) and maintaining these new sustainability requirements.

This instrument provides the legal framework for implementing other sustainability measures, such as traceability systems, price premiums on sustainability practices, audits, and educational programmes.

4.2.4   Instrument 4: Price Premiums

The economic pressures often hinder coffee farmers, especially smallholders, from adopting sustainable and deforestation-free practices. The costs associated with transitioning to and maintaining these practices can be significant, while the benefits may not be immediately apparent. Price premiums can address this challenge by providing direct financial incentives for sustainable practices. A collaborative approach for developing a price premium programme through dialogue with farmers and other supply chain actors should be considered, so that it effectively meets their needs. Key elements include stakeholder engagement through dialogues with farmers and intermediaries, participatory impact assessments, transparent communication channels, and capacity-building initiatives.

While the collaborative approach aims to create an equitable and effective premium programme that genuinely supports sustainable practices while benefiting all stakeholders in the coffee supply chain, the primary goal is to incentivise farmers to adopt and maintain deforestation-free practices by making them economically viable and attractive. For deforestation-free practices, a price premium can compensate farmers for deliberately foregoing expansion into forested areas, ensuring this approach is economically viable. At the same time, it promotes sustainable techniques on existing farmland to enhance productivity without expansion. This dual approach recognises that avoiding deforestation requires specific incentives beyond general sustainability measures. Traceability systems will help prevent the risk of farmers selling deforestation-free coffee to the EU while clearing forests for production destined elsewhere. The expected outcomes are increased adoption of sustainable and deforestation-free practices, improved farmer livelihoods, reduced pressure on forests, and a stable supply of verifiably deforestation-free coffee.

Key actors and their roles are provided in Table 7:

Table 7:   **Key actors and actions for implementing price premiums**

Key Actors	Actions for Implementation
Company	- Develop financial models for premium pricing that can accommodate input from farmers and supply chain actors, assess the impact on overall coffee costs and company finances, allocate adequate budget for the premium programme (i.e. to provide meaningful incentives while remaining financially sustainable for the company), collaborate with the sustainability and procurement teams to integrate the premium system into existing financial processes (finance department). - Define criteria for premium eligibility linked to deforestation-free practices, develop verification processes for premium qualification, monitor the environmental impact of the premium programme (sustainability team). - Integrate premiums into purchasing processes, communicate premium structure to suppliers and farmers, and monitor the impact of premiums on sourcing and quality (procurement team). - Conduct market research on consumer willingness to pay for sustainable coffee, develop strategies to communicate the value of premiums to consumers, and create campaigns highlighting the impact of premiums on sustainability (marketing team).
Farmers	- Implement and maintain deforestation-free practices, provide necessary documentation and data to qualify for premiums, participate in training and verification/auditing processes.
Intermediaries	- Facilitate the implementation of the premium system with farmers, ensure accurate tracking and distribution of premiums, and provide data on premium impact and farmer participation.

Key strategic levers include clear premium criteria, transparent verification, effective communication of benefits, and integration with other sustainability initiatives.

This instrument is closely linked to responsible contracting, traceability systems, educational programmes, and audit and certification.

4.2.5   Instrument 5: Educational and training programmes for farmers

Small-scale coffee producers, who form a significant part of the supply chain, often face economic pressures and climate change impacts that can drive deforestation. While these farmers generally understand the importance of preserving forests, they may lack information on alternative income sources, methods to increase land productivity, and techniques to adapt to climate change impacts. These knowledge gaps, combined with economic vulnerabilities, can lead to the clearing of additional land as a perceived necessity for survival and growth. Thus, an educational approach is essential.

This instrument aims to empower farmers with knowledge, skills, and resources to implement and maintain sustainable, deforestation-free farming practices. The focus will be on providing

information and training on: 1) diversifying possible income sources to reduce economic pressure on forest lands, 2) implementing advanced agricultural techniques to increase productivity on existing farmland, and 3) adopting climate-smart practices such as improved water management and protection against extreme weather events. By addressing these specific needs, it is expected that there will be increased adoption of sustainable, deforestation-free farming practices, improved farm productivity, enhanced farmer resilience to economic and climate pressures, and the development of a network of knowledgeable farmers who can further disseminate these practices within their communities.

Key actors and their roles are provided in Table 8:

Table 8: **Key actors and actions for implementing educational and training programmes for farmers**

Key Actors	Actions for Implementation
Company	- Ensure training content aligns with EUDR requirements and company policies, and develop metrics for measuring training impact on actual deforestation stop or reduction by farmers (sustainability team). - Develop curriculum content on sustainable coffee farming, conduct training sessions and provide technical advice, and assess the effectiveness of training programmes (agricultural experts from the companies or external from agricultural institution/consulting firms).
Company representatives in supply countries	- Coordinate training activities with local actors, ensure alignment of training with company sustainability goals, and monitor and report on training outcomes.
NGOs	- Facilitate connections with farmer communities, provide local context and cultural insights for training programmes, assist in programme implementation and monitoring.
Farmer Cooperatives	- Help identify training needs and priorities, facilitate farmer participation in training programmes, and provide feedback on programme effectiveness
Farmers	- Participate in training programmes, implement learned practices on their farms, and share knowledge with other farmers in their communities.

The educational programme relies on resources including a comprehensive training curriculum developed by agricultural experts and the sustainability team, a network of local trainers from local institutions/consulting firms, and partnership with NGOs, demonstration farms in key regions. Success will be driven by key levers such as a participatory approach to curriculum development, practical hands-on training methods, use of local languages and contexts, and the integration of traditional knowledge with modern sustainable practices.

This instrument is connected to traceability systems, responsible contracting, price premiums, and audit and certification.

4.2.6 Instrument 6: Environmental performance platforms

Robust audit (both internal and third-party) and certification processes are crucial for ensuring compliance, maintaining credibility, and driving continuous improvement in sustainability practices throughout the supply chain. The coffee industry employs a range of certifications to promote sustainability and ethical practices throughout the supply chain. Key certifications include Fair Trade (Fairtrade International 2024), which ensures fair prices and working conditions; Organic (such as USDA (USDA Organic 2024) and EU Organic (EU 2018)), focusing on environmentally friendly farming without synthetic inputs; Rainforest Alliance, emphasising environmental conservation and social responsibility; 4C (Common Code for the Coffee Community), an independent standard for sustainability; C.A.F.E. Practices (Starbucks 2020), developed by Starbucks to assess economic, social, and environmental aspects; and Bird Friendly (Smithsonian's National Zoo and Conservation Biology Institute 2024), certified by the Smithsonian Migratory Bird Center for shade-grown coffee supporting biodiversity. These certifications often overlap, with many producers holding multiple certifications to address various aspects of sustainability. They are typically verified by independent third-party auditors and provide frameworks for continuous improvement in areas such as fair-trade practices, organic farming, environmental conservation, and ethical labour practices. Among these certifications, Rainforest Alliance covers aspects of deforestation. The Bird Friendly certification, given its nature, likely addresses deforestation as well. The rest of certifications do not cover the aspects of deforestation explicitly. While formal certifications are important, some specialty coffee companies also use these standards as guidelines to improve their practices without formal certification, contributing to a more sustainable and ethical coffee industry overall.

Key actors and their roles are provided in Table 9:

Table 9: Key actors and actions for implementing audit and certification processes

Key Actors	Actions for Implementation
Company	- Develop internal audit protocols aligned with EUDR and company standards and targets, coordinate with external auditors and certification bodies, analyse audit results and develop improvement strategies (quality assurance and sustainability team). - Analyse audit results and develop corrective action plans to address systematic deviations identified in audits (sustainability team). - Ensure audit processes meet legal requirements, including EUDR, and review audit findings for potential legal risks or compliance issues (legal team).
External (Third-party) Auditors	- Conduct independent audits, provide objective assessment of compliance and sustainability practices, and offer recommendations for improvement based on industry best practices.
Certification bodies	- Provide recognised sustainability certifications (e.g., Rainforest Alliance, Fairtrade), and conduct certification audits and verify compliance with standards.
Farmers Intermediaries	- Prepare for and participate in audits and certification processes, implement corrective actions based on audit

Key Actors	Actions for Implementation
	findings, and maintain records and documentation required for audits.

Implementing this instrument will be supported by resources including detailed protocols and checklists developed collaboratively, trained internal auditors complemented by external ones, educational materials for suppliers, and allocated budget for certifications and external audits. Keys to success are clear communication of audit criteria, seamless integration of audit processes into daily operations, efficient use of technology for data handling, and fostering continuous improvement throughout the organisation and its supply chain. To address the financial aspects of certification, various cost-sharing approaches can be considered. These include a tiered contribution system based on supplier size and volume, performance-based incentives, a co-investment model for necessary improvements, support for group certification among smallholders, and partnerships with financial institutions to provide low-interest loans. A portion of the premium received for certified coffee might be reinvested into the certification process and shared with suppliers. This multi-faceted approach aims to distribute the financial burden fairly, align incentives for maintaining high standards, and ensure long-term commitment to sustainable practices across the entire supply chain.

This instrument is connected to other instruments, such as traceability systems, responsible contracting, educational programmes, and price premiums.

4.3   Discussion of the roadmap for the coffee supply chain

This roadmap for achieving deforestation-free targets and EUDR compliance is built on a series of interconnected SSCM instruments. These instruments work together synergistically to address the complex challenges of sustainable coffee production. At the core of this system is the enhanced data management and traceability system, which forms the foundation for all other initiatives. This system enables end-to-end traceability from individual farms to the final consumer product, supporting EUDR compliance and providing transparency throughout the supply chain.

Building on this foundation, responsible contracting establishes a legally binding framework for sustainability. This ensures that all suppliers, including intermediaries, commit to deforestation-free practices, reducing risks of non-compliance with EUDR. Educational and training programmes complement these efforts by empowering farmers with the knowledge and skills necessary to implement sustainable, deforestation-free farming practices.

Price premium system can be deployed to incentivise these sustainable practices. This instrument provides direct financial incentives for farmers to adopt and maintain deforestation-free practices, making them economically viable and attractive. The effectiveness of these initiatives is verified through robust audit and certification processes, which ensure compliance with EUDR requirements and company sustainability standards.

Given that the burden of compliance often falls disproportionately on producers, particularly smallholder farmers, in particular in terms of the cost for implementation, several instruments need to be implemented as complements to each other, such as price premiums, traceability, and educational programmes.

Underpinning all these instruments is extensive stakeholder collaboration. This involves coordinating efforts across a comprehensive network of stakeholders, including the company (and its internal departments), farmers, suppliers, NGOs, local governments, and industry

partners. This collaborative approach is crucial for developing and implementing successful sustainability strategies, particularly in the context of complying with the EUDR.

For the effective implementation of this roadmap, various stakeholders have specific roles. Farmers are expected to implement and maintain deforestation-free practices, provide necessary documentation, and participate in training programmes. Intermediaries facilitate the premium system implementation and ensure accurate data tracking. External auditors and certification bodies conduct independent assessments, while NGOs and local organisations assist in programme implementation and provide local context. Industry partners collaborate on sector-wide initiatives, local governments create supportive policy environments, and consumers provide feedback and participate in awareness campaigns.

Some necessary adaptations to the regulatory, especially local regulations, and market framework could support the roadmap's implementation. These include simplifying compliance processes for smallholder farmers, developing support mechanisms to help farmers cope with climate change impacts and economic pressures, improving integration of intermediaries' databases, creating policies to support the transition to sustainable practices, and establishing market incentives for deforestation-free coffee.

This comprehensive and integrated approach can achieve deforestation-free targets, ensure EUDR compliance, and contribute to the long-term sustainability of the coffee industry.

List of references

This report is a compilation of content from the following research reports. The literature cited in this report is accessible in the list of references of the respective reports.

Grüning, C., Jüde, J., Martin, K., Strasser, J., Tran, C., Grabs, J. (2025): *Cost allocation and incentive mechanisms for environmental, climate protection and resource conservation along global supply chains. Roadmaps for the implementation of sustainable supply chain management approaches and instruments*. German Environment Agency (Hrsg.). Texte 04/2025. https://doi.org/10.60810/openumwelt-7704

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